HOUSE ORGAN OF ALLOYS GENERAL ALLOYS COMPANY

EDITED BY [signature] PRESIDENT

ALLOY PROGRESS

Bright Spot in Metal Progress

We haven't any particular gripe about reciprocity in its direct effect upon our business. Our sales volume and average prices are materially higher than any "Reciprocity" competition.

We can't complain about the business we've had a fair chance to get, but the phony inquiry act put on by some reciprocity-bound purchasing agents on business already "in the bag" is just as crooked as taking your money by any other fraud or misrepresentation, unless you hold that salesmen's and engineers' time and traveling expenses aren't money.

What really bothers us about Reciprocity is that we believe these under-the-table and off-the-bottom-of-the-deck connivances of some of the larger corporations constitute a really vulnerable point in big business, laying open invitation to congressional investigation. "To protect the equities of stockholders, create free competition, prevent connivance in restraint of trade."

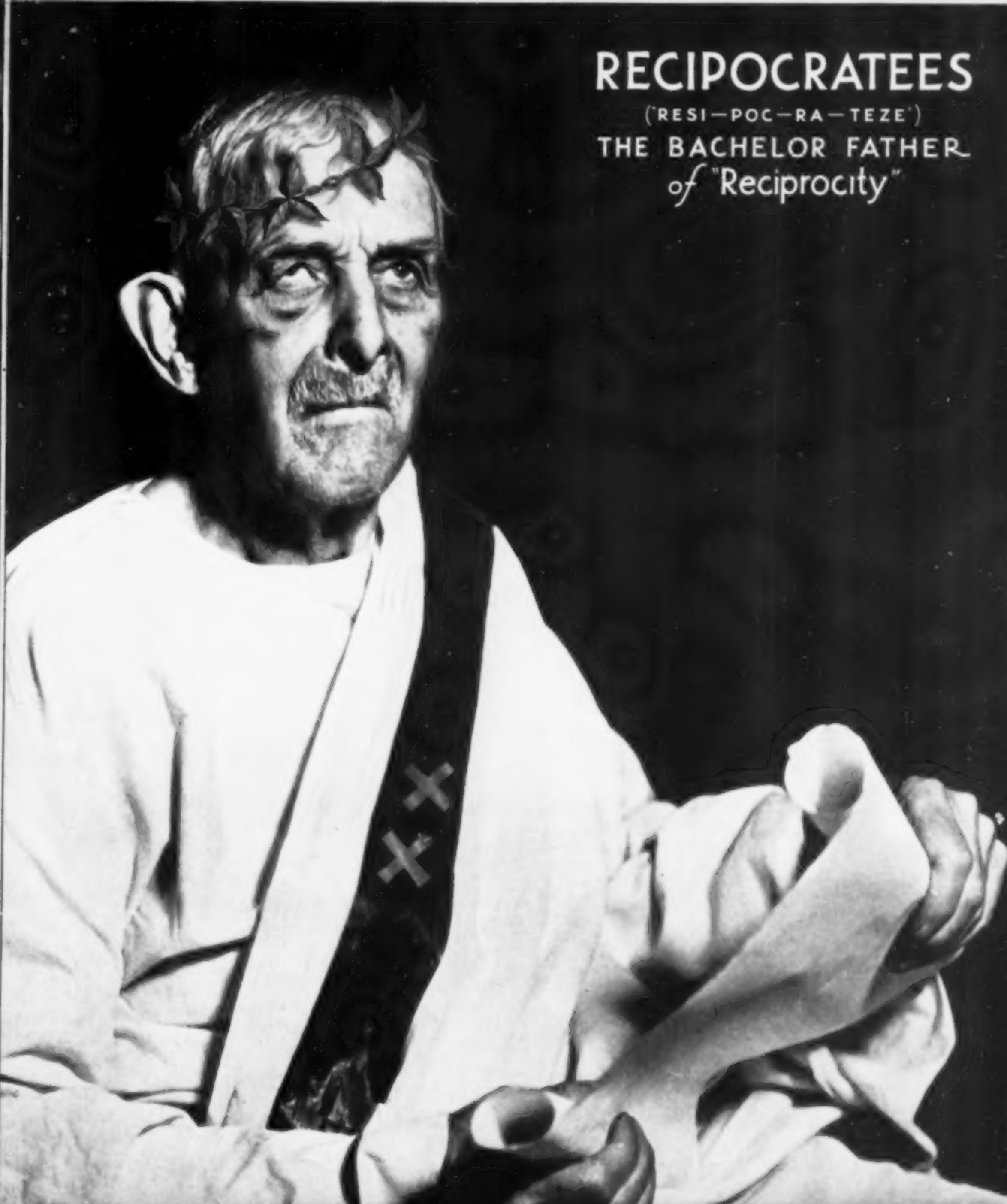
Every time the Politicians take another whack at "Big Business," or try to "Help the Little Fellow," they are apt to raise Hell with business in general. Reciprocity always was a two-edged sword, but its hazards now far outweigh its "Advantages."

(A print of Recipocratees sent with our compliments to anyone writing on his business letterhead, while they last.)

PLEASE

See that Your Company Sends Your Inquiries for Heat-Corrosion and Abrasion-Resistant Castings to General Alloys

THANKS!



Wreathed in poison ivy sits the Perverse Progenitor of a Thousand Evils.
He would prostitute the Purchasing Agent, degrade the Salesman, ignore the Engineer.
He swaps the equities of Stockholders without their Knowledge or Consent.
The Doctrine of Reciprocity was plagiarized from the Chinese, originators of the twin backscratchers.
Carried to its ultimate conclusion we would be taking in each other's washing.
American Industry was built by Science, Initiative, Merit and Competition—still a good formula.
Eject the rotten apples from the basket—before our business ethics fall to the level of politics.

[signature]
PRESIDENT GENERAL ALLOYS COMPANY, BOSTON

GENERAL ALLOYS HAVE GROWN TO THE OLDEST AND LARGEST EXCLUSIVE MANUFACTURERS OF HEAT AND CORROSION RESISTANT ALLOY CASTINGS WITHOUT RECIPROCITY. WE SOLICIT YOUR BUSINESS ON A BASIS OF UNEQUALED EXPERIENCE.

ACCORDING to Baldomero Barbara Filho (Filho = Jr.), my friend from Rio, centrifugal casting originated in Brazil when his father was a boy. Today all the pipe made in Brazil is centrifugally cast, from 1" diameter up, and some with the threads. The Brazilian machines for the small sizes rotate at terrific speeds. Some are refrigerated. Brazilian practice, on the small sizes, is materially ahead of anything we are doing. Incidentally, we have never seen any centrifugally cast thin wall alloy tube in diameters over 8" that didn't leak freely under heat. The thick wall or small diameter tubes are good within definite

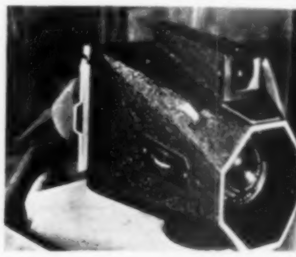
limitations. Centrifugally cast carburizing boxes are to date vastly inferior to good sand castings. Having no core the structure is bilaminar instead of trilaminar, a fault that is accentuated in thin section.

BEING an Illinois dirt farmer, fourth generation raising cattle on the same land, I gripe at the deluge of Brazilian corned beef sold under Armour's label, and the Kelloggs corn flakes marked "Made in Canada" on sale everywhere. Farmers hear speeches, ignore trade statistics. Smart Brazilians and Canadians tax your product and ours heavily.

CUTTING across the lake from Sandusky to Detroit, at about 12,000 feet altitude, I got a shot at South Bass Island, from the center of which rises the granite shaft of Commodore Perry's Monument at Put-in-Bay. Looks passably like the American Continent. Last time I put in to Put-in-Bay, with the Yacht Mindoro, her 4,000 feet of canvas carried a 1" "Frosting" of June Bugs. We shoveled them off the deck while the harbour was illuminated by burning bug pyres ashore. "Boardin' bugs bring bad fortune" said Olaf, m[y] ... That fall I sold her, and she was l[ost with] all hands in the Caribbean.

HERE'S the latest thing in Aerial C[ameras,] the first model "D" SKY-VIE[W] delivered, which has adjustable ... take pictures on the ground as w[ell as in] the air. It will speak for itsel[f in later] issues.

A VISITING Brazilian was jus[t ...] on English, and had been told ... poetry, memorize songs, write d[own ...]



translate signs. After a trip t[o ...] on the Century he was humm[ing] HUMORESQUE and trying to sin[g ...] written on the back of an envelo[pe ...] words fitted the music nicely, ... yourself.

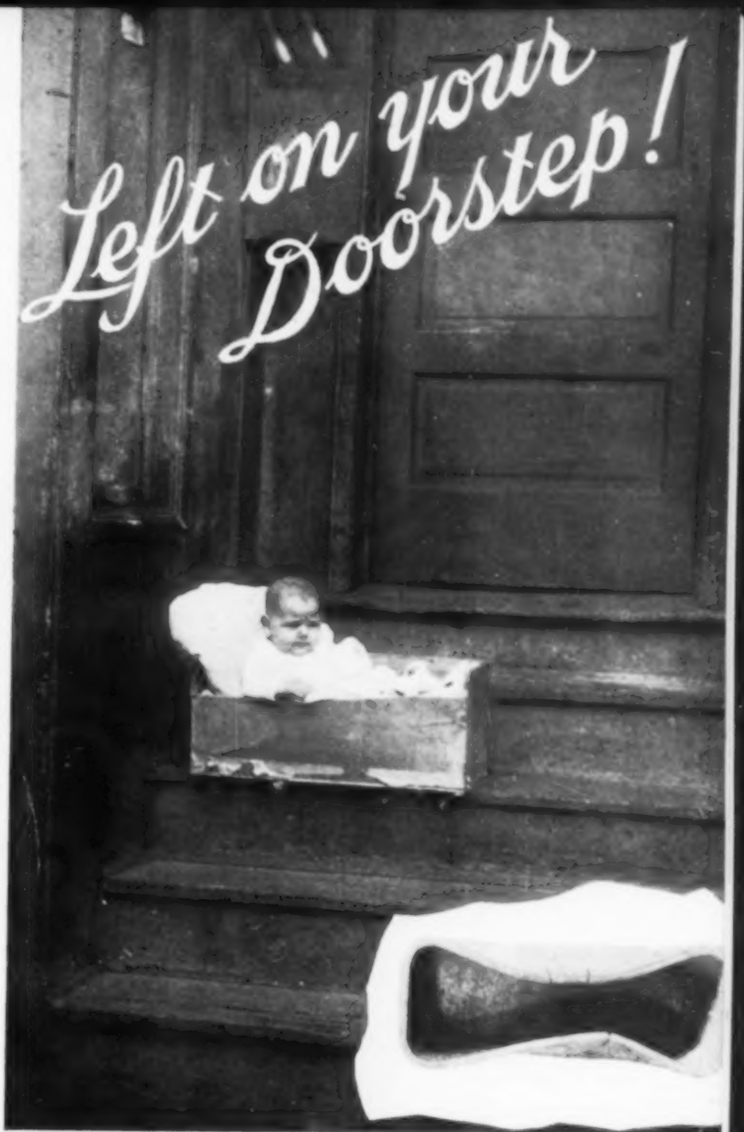
"PASS-EN-GERS will please re[frain] from flush-ing toi-lets,—while th[e train] is stand-ing in the station—I lo[ve you]" ("I love you" is first 3 English ...) learned by visiting Latins).

THE largest barrel of Rye in th[e ...] flashed into my mind as I looked d[own on] this colossal container,—just ful[l] —at Rye, N. Y. I've kidded pa[...] about this, and made it stick.

YES, to a score or more queries, ... the Great Dane, pulled out of his ... monia, lies curled at my feet as I ... this out on a new portable, 2¼" ... including case.

WE HOPE THAT YOU

were not among those who bought depression furnaces at depression prices equipt with depression alloy. Then, there *might* have been some excuse for buying "Cheap" alloy from second rate outfits, to save pennies in first cost.
Lots of "New Babies" have been left on people's door steps, in the guise of "Economy," most of them of doubtful parentage.
Help raise anybody's baby if you like punishment!
If you prefer not to experiment, however, you can specify "General Alloys Alloys," and be sure of dependable service, proven economy, HIGHEST QUALITY.



B...ARR MACFADDEN's Physical Culture ...el at Dansville, N. Y., is unique. ...ere love-starved women and anaemic ...nquer frustration," quips one inmate. ... the Night Watchman, "America's ...test Diplomat," says that everybody ...o goes there feels whambunctious on ...e food, sound hokum, "rational living." ...sville has a good airport, and I knock ... a turkish bath enroute East-West. ...ile somewhat less exclusive than Grand ...tral Station, Macfadden's P. C. Hotel ...s years to lives,—if you don't laugh ...rself to death. The Password is ...neal or Enema."

HIGH TEMPERATURE FANS are finding increased use. Running at high speeds, they must be balanced statically and dynamically for maximum speed and temperature conditions. Fine foundry practice is required, plus Engineering. G. A. has both.

...AKE half cup molasses, half cup honey, ... tablespoons sugar, two tablespoons ...gar, one teaspoon salt. Boil till it ...s a soft ball in cold water. Add but-... size of egg and boil, stirring, till it ...ens in cold water. Pour this over ... crisped puffed rice, and you have an ...enitic ellipsodized tart-sweet of Q-Alloy ...ity.

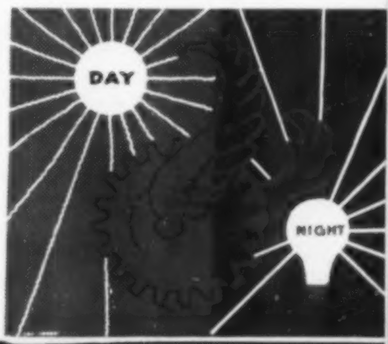
W...HITEY MAURATH made a tragi-comic ...ake. In his "Caruso in the Monkey ...se" picture in April *Metal Progress*, ...ey was on the wrong side of the bars.

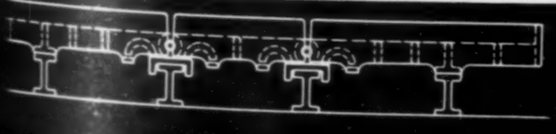
C...ARBURIZING boxes can be packed with ... to 25% more work by separating the ...s of work with thin one-ply fir veneer ...ad of compound. Put a layer of com-...d on the bottom, then a layer of work, ...with compound even with the top of ...ayer of work, *but not over the work*, ... the sheet of veneer, and another ... of work with compound flush,— ...at for each layer until the top, which ...ld have an inch of compound over ...work.

D. Y. GUARDIAN, the old tub I live on ...r and summer, when on the Eastern ...ard, having been delivered by Cae-...n of a quadruple expansion steam ...e, is now taking aboard a pair of ...n Diesels. I will probably be too ... flying to run them this year.

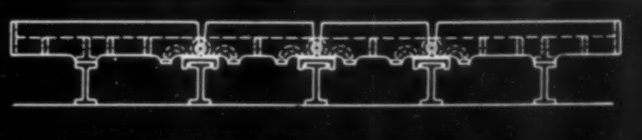
SNOWED UNDER

WITH ORDERS. Working Night and Day to fill the largest backlog of unfilled orders in our history, and rushing new buildings and equipment to improve quality and service, General Alloys says "THANKS!" and promises unimpaired quality, reasonable deliveries.





...in hinge 4-rail tray will weigh approximately 60 lbs.



A three hinge 5-rail tray will weigh approximately 48 lbs.

THE SAVING IS OBVIOUS

HUNDREDS of ELECTRIC FURNACE COMPANY'S Electric and Fuel Fired Furnaces in operation today have paid for themselves many many times over. In a large Agricultural Machinery plant the above furnace has run over ten years with the original General Alloys Roller Rails.

WHEN you investigate the unexcelled records of Electric Furnace Company's Gas, Oil, and Electric Furnaces, check up on those veteran pre-depression furnaces and you'll find three out of four of them equipt with Q-Alloy and X-ite mechanism. The splendid reputation of this pioneer builder of modern mechanical furnaces is based on dependable, economical performance, a reputation largely built on furnaces equipt with General Alloys cast mechanism. While these furnaces carry a standard one year guarantee, the average life of the General Alloys parts is from six to twelve years.

IN the light of such records, can you think of any reason for not specifying General Alloys Castings, Q-Alloy, or X-ite, on your new furnaces.

TUMBLE B

OH, he sailed o'er the snow with
greatest of ease, the perspiring
man in the fur B.V.D.'s, he cut
didoes, was stealing the show,
the bugs set him down, on his
the snow.

NON-PLUSSED for the
groped for his staff, and gathered
like a handful of chaff, for the
had exploded like poor alloy
while George was collecting the
from the Rubes.

DESIGNED by Providence as a
pression member, bamboo pole
been tested by countless genera
monkeys and baboons before
McCormick got his, a ski pole
plete with a set of Yodeling
by-ear-by-mail, a pair of
skis, and plaid wenching pants
this worm turned. Furthermore
kept right on turning
bamboo ski-pole, and each
took a deeper cut,—the pole
bug, inside the bamboo pole,
it to a shell, note macrograph

A Prophecy

Widening Markets Point
An "Age Of Stainless Ste

PERHAPS we are over-optimis
view of the amazing expansion
steel into practically every
few brief years that this valuable
been available commercially, it
tion that an "Age of Stainless
soon rank in importance with the
Bronze Age and Iron Age.

Because of our familiarity
merits of stainless steel, it is
difficult to curb our enthusiasm
ture possibilities. However,
desiring statistical facts, the
prove indicative of what is to
streamlined trains alone
stainless steel as was produced
try in 1926; consumption in the
try has grown from a total
twenty tons in 1930 to nearly
1936; one concern that manufa
stainless steel cooking utensils
of 1932 now makes this number

Indicative of the alloy
eral is the following statement
dent of one of the well known
nies concerning the total tonnage
company during 1935: "
sisted of alloy steels which were
unknown to the metallurgical
best were laboratory curiosities
1919." *Electronics Review*

GENERAL ALLOYS COMPANY

367-405 W. FIRST ST., BOSTON, MASSACHUSETTS, U. S. A.

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BOSTON, MASS.
CHAMPAIGN, ILL.

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PHILADELPHIA W. T.

OLDEST AND LARGEST EXCLUSIVE MANUFACTURER OF HEAT & CORROSION RESISTANT AL

Temperature Effects

(Continued from page 510)

changes brought about by prolonged heating are well known to metallurgists, and such changes may develop new properties which must be taken into account. The loss of impact strength which may occur after holding steels at embrittling temperatures is not revealed until cooled to room temperature. Toughness is restored by proper reheating.

In addition to phase changes, an intergranular penetration by gases has lately been noticed; it lowers elongation and occurs without apparent surface deterioration. Chromium, the antidote for oxidation, seems helpful against this difficulty.

The following is offered as a safe generalization for service up to visible redness: For resistance to deformation alone and in the absence of marked attack by surrounding media, carbon steels containing molybdenum may be used. For greater chemical inertness, from 2 to 9% chromium is used as the principal alloying element, with its resistance to creep reinforced chiefly by molybdenum, tungsten or both.

A low red heat (say 1100 or 1200° F.) seems to be the limiting value for the above class of phenomena for the reason that below such a temperature the surface attack is ordinarily not serious and some steels are so markedly superior in creep resistance as to compel their use. On the other hand, above a red heat, all steels tend to reach the same very low degree of tensile strength, and resistance to hot gases becomes the determining criterion of serviceability — with enough metal needed to take care of the stress. Because of their toughness, with excellent resistance to "sour" crude oils, we find the 5% range of chromium steels used in oil refinery still tubes at temperatures barely above a red heat. For certain vapor-phase cracking we may find temperatures as high as 1650° F., and here the very high chromium steels are in use.

Oxidation resistance of, say, 28% chromium steel is not due to its intrinsic "nobility" toward hot oxygen, but rather because of the protecting scales formed, and their ability to seal off the penetration of hot oxygen by their enamel-like characteristics, which must meet many requirements of density, impermeability to gases, resistance to thermal fatigue and coefficient of expansion. For surface stability at high temperatures, 20% and more of chromium is generally used with or without nickel. Surface stability may be imparted by titanium or aluminum, in which case the chromium may be lower than in the preceding categories.

Stabilization against susceptibility to embrittlement is imparted by molybdenum, titanium and particularly columbium.

Low Draw

(Cont. from page 534) of stress (the transformation of α martensite into β martensite), and the formation of cubic α-iron lattice. Hardness, strength and toughness increase to a maximum as a result of this precipitation hardening.

Second stage (from about 300° F. to about 500° F.): Continuing growth of coarser carbide particles causes a drop of strength and toughness. Simultaneous decomposition of retained austenite also decreases the toughness. It also tends to increase the strength of the steel, but this influence, as well as its associated carbide coagulation, is fully counterbalanced by the continuous decomposition of the martensite. Thus, it is again shown that in structural alloy steels the *amount* of retained austenite plays a less important role than the amount of carbides fixed in solid solution by quenching, and precipitated during tempering.

Third stage (above 500° F., more or less, to Ac_1): The decomposition of martensite (decarburization of hexagonal alpha iron) gradually becomes complete, and the coagulation of carbides has the predominating influence on the mechanical properties of steel. The strength continues to decrease and the toughness increases, having passed its minimum.

As the transformations at low temperatures proceed slowly, prolonged soaking at any temperature is equal to a shorter soaking at a somewhat higher one.

All the phenomena described become more evident with the increase in the amount of carbides fixed in the solid solution by quenching from a higher and higher temperature. The increase of hardening temperature is limited by the austenitic grain growth, and the gain in toughness to be had in the described manner is rather small in the case of coarse-grained steels. The influence of overheating (grain growth) will more or less prevent a gain in toughness in the first stage of tempering, as is shown by Luerssen and Greene's investigations on coarse-grained tool steels (see, for instance, *Transactions* ⚙, 1934 and 1935).

In the author's opinion, the difference in grain size is the true cause of variable results in the toughness versus tempering curves obtained by various investigators.

B. Sheinin

Electrical and magnetic alloys of iron, nickel, cobalt and chromium must be melted and heat treated in closely controlled atmospheres. This article describes Westinghouse's department for doing this and contains much information on the gas preparation and control

Melting and Annealing of Electrical Alloys

A GROWING GROUP of special alloys has become important in the manufacture of electrical products. They are for the most part made from relatively expensive ingredients, such as nickel or cobalt, and perform some technical function in present-day apparatus. In contrast with alloys devised for mechanical strength or structural stability, they are designed to have special magnetic, electrical, or thermal characteristics. They are produced in small quantities, in comparison with tonnage steels, although their dollar value is high. They assume their vital position because they fill a technical requirement around which a whole device is designed.

A few of these materials familiar to electrical engineers and with which the authors have had experience are:

Hipernik — High permeability, low-loss magnetic alloy of iron, nickel, manganese, and silicon. Used for current transformers, relays, and similar devices.

Kovar — Alloy of iron, nickel and cobalt, having thermal expansion equal to glass and being readily "wet" by molten glass. Used for metal-to-glass seals in electronic tubes.

By D. F. Miner and J. B. Seastone
Engineering Division
Westinghouse Electric & Mfg. Co.
East Pittsburgh, Pa.

Cupaloy — Alloy of copper and chromium having high strength and hardness. Used for high strength, current carrying parts of rotating machines and for spot welder electrodes.

Konal — Alloy of nickel and cobalt having high emissivity and strength at high temperature, for electronic tube cathodes and springs.

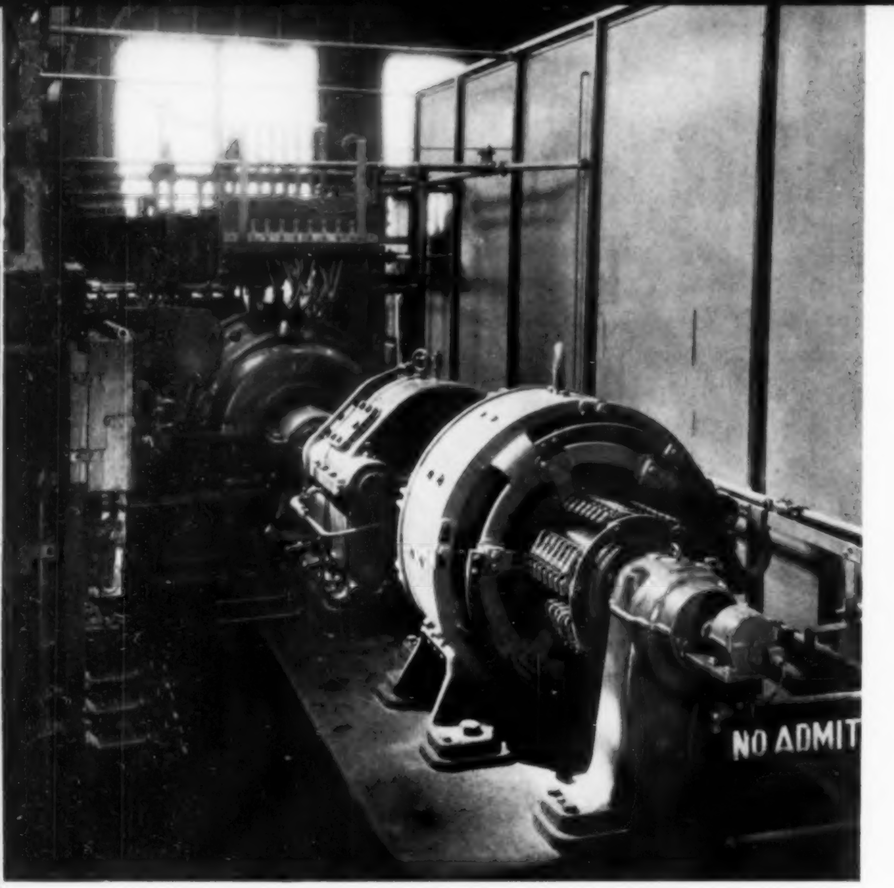
Modified Invar — Magnetic material with properties sensitive to temperature changes. Used for relays.

Electrical energy plays an important part in the fabrication of these alloys, chiefly in the melting and heat treating operations. Melting in an induction furnace permits an accurate control of composition, a correct temperature control and the use of special gaseous atmospheres. Electric annealing or other heat treatment is a convenient and economical means of providing precise cycles of heating and cooling with atmospheric and moisture control.

A description of the plant installed by Westinghouse Electric & Mfg. Co. and equipped to make the alloys mentioned will be given to illustrate the part electricity plays in a practical solution of some special and difficult metallurgical problems.

Requirements of Alloy Manufacture

Let us first examine three of the above mentioned alloys and consider the factors requiring special control in these cases. Hipernik is an alloy of iron and nickel, in approximately equal



Power Plant for High Frequency Induction Furnaces. Main equipment is motor-generator set for d.c. power to drive second motor-generator set producing 5000-cycle a.c. power. Bank of special capacitors appears at top in background

proportions, to which small quantities of manganese and silicon have been added. (See T. D. Yensen's articles in *Journal* of the Franklin Institute, 1925, and METAL PROGRESS, June 1932.) The alloy is useful because of its high initial and maximum permeability, and because of its low hysteresis loss — both important items in current transformers.

The relative quantities of the ingredients in the alloy are not critical. For example, the nickel may range between 47 and 52% and the manganese between 0.5 and 2.0% with no appreciable effect on the desired characteristics. However, the significant characteristics of hipernik are exceedingly sensitive to the oxygen and sulphur content and to a lesser degree to carbon contamination. Changes in oxygen so small as to defy measurement may produce a change in the maximum permeability from 20,000 to over 100,000. This represents, of course, a five-fold change in properties.

As another example, consider kovar, an alloy of iron, nickel and cobalt used in sealing glass with a high softening temperature. It was developed in the Westinghouse Research Laboratories by Howard Scott and has been described in *Journal* of the Franklin Institute, December 1935. Other materials are not so satisfactory for this application because thermionic tubes must be exhausted at high temperature and the available materials either do not match the expansion characteristics of the hard glass required for this service or are so expensive as to be impracticable. It is essential that the expansion characteristics of the metal closely match those of the glass over the operating and fabricating temperature ranges, and this is, of course, especially true for large tubes. Smaller pieces, such as the glass-to-metal seals used in metal radio receiving tubes, are far less critical but a high order of similarity is still desirable.

The expansion characteristics of kovar are critically dependent on exceedingly close control of composition. The desired match between metal and glass expansivities is most nearly achieved (with glass available commercially) when the mean expansivity between room temperature and the inflection temperature of the glass (450° C. or 850° F.) is about 4.5×10^{-6}. A very small change in composition is sufficient to raise this to a value that would prevent a satisfactory seal in a large tube. The problem is further complicated by the fact that, in common with other high nickel alloys, the workability of the material is sensitive to contamination by sulphur. It is not practicable to counteract sulphur, particularly in the presence of oxygen, by means of manganese additions (as is frequently possible) because of its adverse effect on the expansivity.

Oxidation Losses Reduced

Still another instance is cupaloy, an age hardenable copper alloy. In melting, prior to casting in ordinary foundry equipment, chromium must be added in the form of a chromium-rich copper master alloy. This master alloy is difficult to prepare, not because of requirements as to controlled composition, nor because of sensitivity to the presence of impurities, but because of the very high chemical activity of the chromium and the fact that a proper mixture is not formed except at exceedingly high temperatures. With ordinary melting equipment such as gas furnaces, a large part of the chromium would be oxidized and its price is so high as to make this loss prohibitive.

In brief, then, we may find electric melting or annealing equipment advantageous *(a)* when impurities must be held to very low values, as in hipernik, *(b)* when composition must be very closely controlled, as in kovar, or *(c)* when

specially difficult temperature conditions are coupled with high chemical activity, as in the copper-chromium hardener.

Melting Equipment

The metallurgical equipment in the alloy plant may be considered under two heads, the melting equipment and the annealing apparatus. The melting equipment comprises an alternator and power supply, capacitors, and the high frequency furnaces.

The alternator is a low voltage, high frequency machine of the inductor type, which supplies about 150 kva. at 5000 cycles; it is driven by a variable speed direct current motor and this motor obtains its power from a variable voltage, direct current generator which is in turn driven from the 60-cycle supply by a synchronous motor. This arrangement permits a very flexible speed or frequency control. The furnaces, which constitute a highly reactive load, are coupled to the alternator through a capacitor unit and the entire circuit is ordinarily operated near the point of series resonance.

The capacitor unit is as yet experimental, and employs new equipment. A rating of 43 kva. is secured in a unit only 13¾ in. high, 13½ in. long, and 5 in. wide. This is accomplished by cooling the capacitor units by means of internal cooling coils placed within the capacitor case and operates by markedly reducing the temperature gradient within the unit. Eight series-connected banks, each consisting of six 550-volt capacitors are connected in parallel. The capacity in use is varied by circuit breakers to cut out the banks not required; further control is by slight adjustments in frequency.

The high frequency furnaces are more or less conventional types and are various in size. Each has a suitable mechanical supporting structure, a water-cooled helical primary which surrounds the charge and the crucible. The latter may be of magnesite, zirconia, or graphite, depending on the alloy to be melted. The furnaces have tight covers and are ordinarily operated under a hydrogen atmosphere, which may be supplied either of commercial purity or especially purified and dried as the occasion may demand.

Electric melting practice presents five advantages in the semi-commercial manufacture of alloys of the type named: (1). Close control of the time-temperature cycle is possible;

Three Medium Sized Furnaces Idling, and a Larger One Pouring a 260-lb. Ingot of Hipernik (Iron-Nickel Alloy) Into a Chill Mold

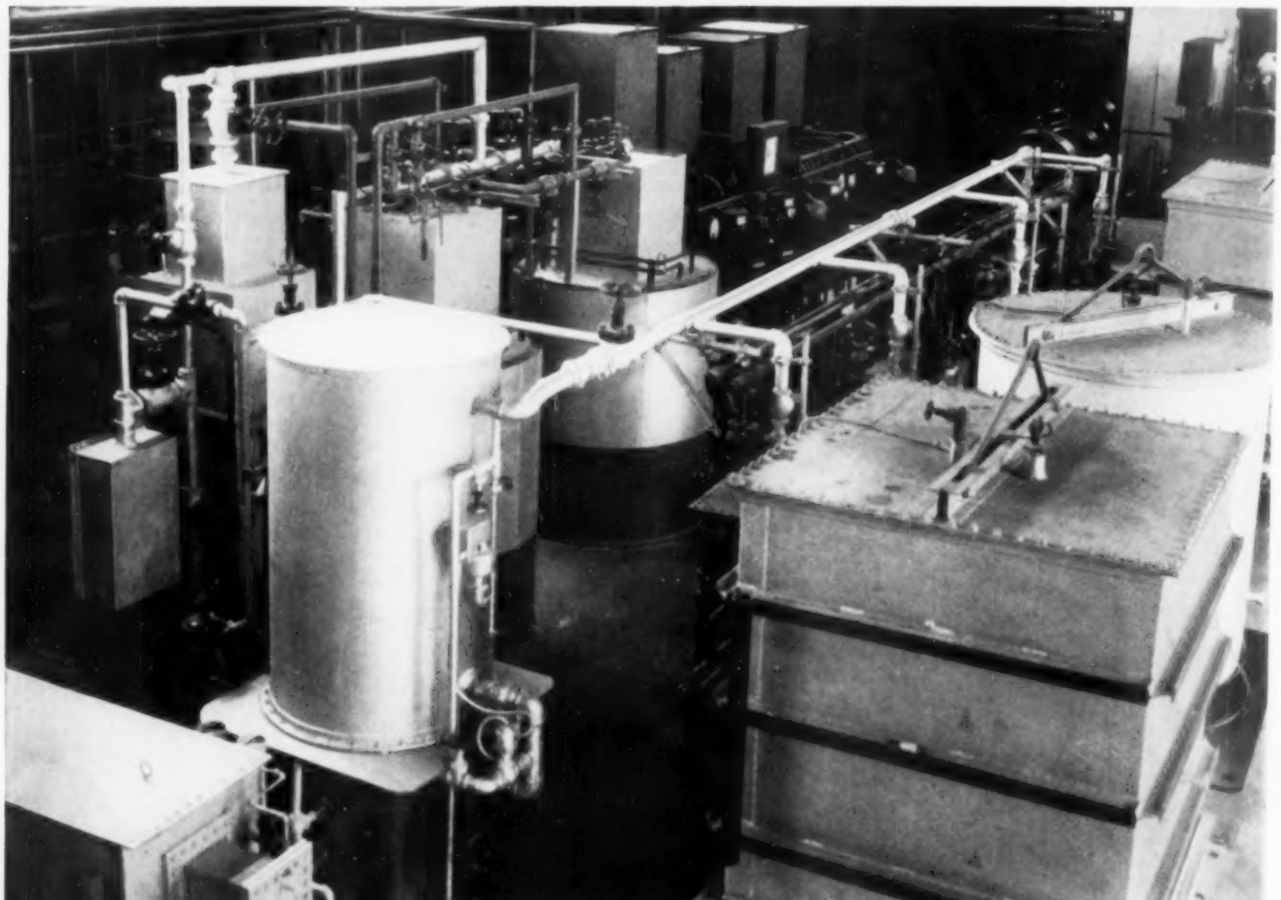
the power input to the furnace is readily controlled and the clean surface of the melt permits accurate temperature determination. (2). There is no contamination from fuel nor from electrodes and it is possible to produce a melt of substantially higher purity than is possible by other methods. (3). The magnetic field set up by the high frequency current in the coil causes a moderate amount of stirring in the melt and this tends toward a very uniform product. If slags are used, this stirring accelerates the reaction at the slag surface. (4). The loss of chemically active elements is very small, due to the fact that the furnace can be tightly closed and operated under neutral or reducing atmospheres. (5). Marked purification occurs when certain alloys are melted under a blanket of hydrogen.

Experiment has shown that controlled annealing cycles designed to purify some metals and to impart desirable magnetic characteristics to hipernik, for example, must provide *(a)* accurate control of time and temperature cycles, *(b)* a supply of pure moisture-free gas, *(c)* a sufficient volume of gas to scavenge the furnace atmosphere and remove reaction products, *(d)* isolation of the furnace charge from the effects of moisture given off by the refractories in the furnace lining, and *(e)* temperatures high enough to allow chemical reactions to proceed at reasonable velocity.

Annealing Equipment

The annealing equipment consists of four main parts; first, gas circulating and purifying equipment; second, gas control equipment; third, electrical power and control devices, and lastly, the furnaces with their directly associated equipment.

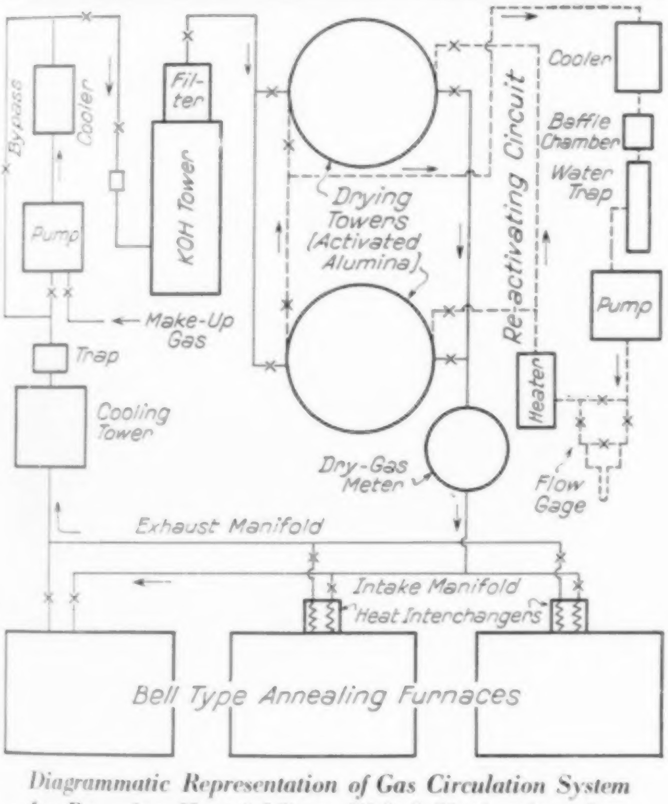
The furnaces are of the conventional bell type and comprise a metal shell with a refrac-



Westinghouse's Department for Making Magnetic and Electrical Metals. At upper right corner are the melting furnaces, separated from the power plant by a screen. At lower right are three large annealers; at left is gas preparation plant and control board

tory lining from which the resistors are suspended. The charge is stacked on a series of iron plates which are supported by pins placed at many points, and the entire assembly is covered by an inner shell of iron. If very high temperatures are used (say up to 1250° C. or 2250° F.) this construction is only possible with furnaces that are no larger than a few tons in capacity.

As has been pointed out, certain cycles require relatively high quantities of gas in order to maintain the atmosphere within the furnaces at the proper purity. This sweeps considerable heat from the furnaces, and economic as well as technical considerations dictate the use of a heat exchanger. These are built as part of the furnace bases and are modifications of a conventional surface condenser, wherein tubes for both incoming and outgoing gases are provided with baffles to facilitate heat transfer.



Diagrammatic Representation of Gas Circulation System for Removing Harmful Gases Picked Up in Annealers, and Auxiliary Circuit for Re-Activating the Alumina

As shown diagrammatically on this page, the gas circulating system is a closed circuit consisting of pump, purifying and drying towers, cooling towers, and metering equipment, connected to main intake and exhaust headers. The annealing furnaces are connected to these headers (in some cases through heat interchangers) and the rates of flow are controlled by valves at the headers.

Gas Purifying System

Gas leaving the furnace through the exhaust manifold passes first through a water cooled tower which lowers its temperature to about 30° C. (85° F.). Under certain conditions of operation moisture is condensed in this cooling unit, and the gas goes through a baffled chamber which throws out any entrained moisture and dust, and then moves into the circulating pump. At the pump the pressure is raised sufficiently to overcome the friction loss in the system, and the gas moves into a second cooling unit which removes the heat of compression. Such coolers are essential since the efficiency of the subsequent driers is dependent upon temperature.

A purifying tower containing moist potassium hydroxide is the next unit in the gas train; in this tower sulphur dioxide, hydrogen sulphide or carbon dioxide are removed if present. The gas then passes into a mechanical filter which consists of a bed of alumina powder. From this it enters one of two drying towers which contain a large body of activated alumina and suitably disposed cooling coils. To insure continuous operation, one drying tower is used while the other is being reactivated. Gas leaving the drying unit passes through a conventional dry type gas meter and then to the inlet manifold.

Successful operation of this system depends largely upon the successful functioning of the equipment for measuring the gas and controlling its flow.

Gas Control for Safety

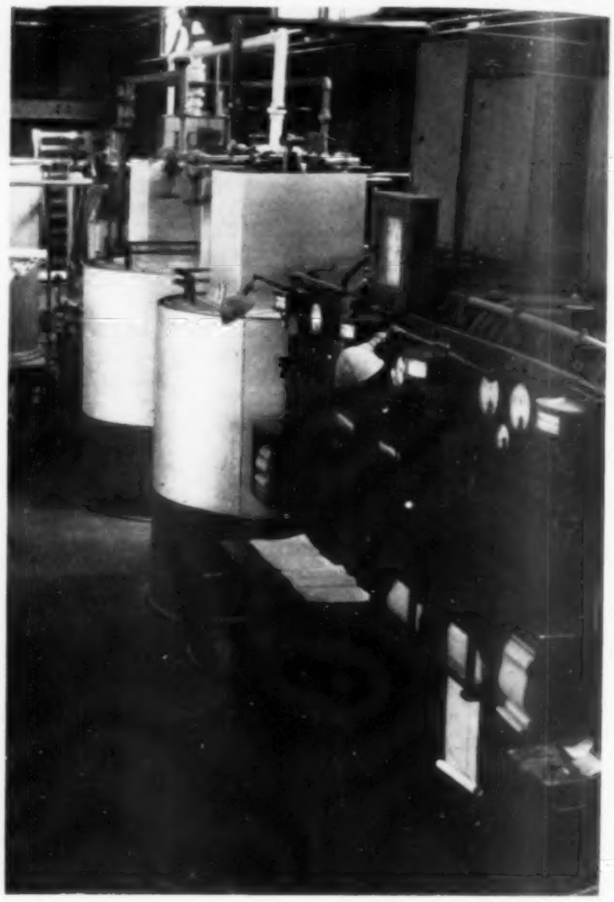
If the usual reducing atmospheres (such as hydrogen, cracked ammonia or cracked natural gas) are used, the purity of the gas is a matter of considerable importance, first as reflecting the safety of operation, and second as an index to furnace conditions. Continuous indications of the composition are obtained by means of a density meter, an instrument which comprises a constant speed, motor-driven centrifugal blower driving a sample of the gas through an orifice,

and a means of measuring the pressure drop across this orifice. The device is quite sensitive. Pure hydrogen gives a reading of 0.28 in. of water, pure nitrogen about 4 in. of water, and each atmosphere that is a combination of these two gives its own definite reading. Inclined liquid pressure gages insure accuracy. The device is also reasonably quick in response, as no more than a minute is required to take in a full sample of gas and to expel substantially all of the previous sample.

Hydrogen or nitrogen, when used, is supplied in cylinders which are connected to high pressure manifolds and from which the pressure is reduced by means of standard gas regulators. This make-up gas at low pressure is admitted to the circulating system at the inlet to the pump which is the point of lowest pressure in this system, and which is always maintained at a small positive pressure with respect to the atmosphere. This is believed to be essential for most reducing gases, to avoid the danger of an explosion if a leak should develop. The pressure differential with respect to external conditions is automatically maintained at a previously determined value, first by a pair of regulating valves of conventional diaphragm type, connected in parallel. If both of these should fail (a rather remote possibility) a pair of electrically operated solenoid valves controlled by a diaphragm type switch come into operation. If the electrically operated valves are required to function for a period exceeding 45 sec., as in the event of a large leak requiring more make-up gas than can be supplied by the pressure operated valves, or by the failure of the diaphragm valves, an alarm is sounded.

Inlet and outlet pump pressures together with the pressure of the make-up gas are also indicated on the control panel (the latter is located directly in front of the desk in the view on this page). If the pressure of the make-up gas should fall below a predetermined limit due to depletion of the supply or failure of primary gas regulators, an alarm is sounded. Under certain operating conditions it is possible to build up an abnormally high pressure in certain parts of the circulating system. If this pressure is not relieved, the furnace seals blow out, and an electrically operated solenoid valve of large capacity, actuated through a pressure control switch, is set to release gas from the system at a predetermined value.

Moisture content of the gas is a factor of paramount importance in annealing some mate-



Equipment for Analyzing Gas Atmosphere and Controlling Its Flow Is on Board Immediately in Front of Desk. Pyrometric control and record of annealers on other panels

rials. Its dryness is checked by accurate measurement of the dew point (which may be far below zero). A dew point meter, developed for this purpose, consists of a glass cylinder terminating in a polished metal cup which is welded to it. This glass cylinder is placed within a larger one and the gas whose moisture content is to be determined is passed through the annular space between the two cylinders. Acetone is placed in the inner metal cup and cooled by dry ice until moisture or frost is seen to condense on its surface. The temperature is then read. The method of measuring dew point is simple and quite accurate since readings can be made to $\pm 2°$ C.

Electrical Power Devices

In actual operation it is frequently necessary to change the volume of the gas being circulated. Smooth control is essential if pressure

surges are to be avoided; this is accomplished by driving the pump with a separately excited, direct current motor. Power is supplied to this motor from a variable voltage, direct current generator which is driven by an induction motor. Further adjustments in gas pressure are accomplished by changing the setting of an electrically driven, motor operated valve which by-passes the pump and is controlled from the central panel.

The photograph shows the control panels at right foreground alongside the two activated alumina towers in the left background. The gas control panels contain, in addition to the density meters (analyser) pressure gages for new gases in cylinders and valve controls and signal lights for them, controls for pumps and by-passes, pump inlet and outlet pressure gages, exhaust valve controls, time delay relays and signal relays. Panels at either side of this one have pyrometric controls and recorders for the various annealing furnaces.

Manufacture of Hipernik

To illustrate the application of the equipment in the manufacture of special alloys, the melting and annealing of hipernik will now be outlined.

A magnesite crucible is placed in the melting furnace and electrolytic nickel, Armco iron, manganese and silicon are weighed, mixed and charged. A blanket of hydrogen is maintained over the charge during the entire melting cycle. After the metal has become molten, the temperature is raised to the proper value for pouring and held for several minutes during which time vigorous stirring is induced, and the hydrogen blanket reacts with the charge and removes impurities. At the end of the holding time a 260-lb. ingot is cast into a chilled mold and the furnace is ready for another charge. This ingot is forged to a billet and rolled into sheet or strip, ready to be stamped into suitable punchings. These are returned for annealing.

The first step in the annealing process is to coat the punchings with a refractory oxide to prevent sticking together. The punchings are stacked in little piles on plates, racked up on the furnace base, and, as a next step in the operation, dried carefully under an open bell. This operation is fundamental to the subsequent heat treatment since if all moisture is not removed at a reasonably low temperature, enough will remain and be evolved while some of the charge is at a very high temperature and subject to spoilage.

The inner cover and furnace bell are then placed over the dried charge and power is applied. Hydrogen is admitted to the furnace at the lowest temperature that is safe (about 650°C. or 1200° F.) and enough gas is passed through the furnace to scavenge it. Inlet and exhaust valves to the manifolds are then opened and the furnace is brought to the annealing temperature. During the entire soaking period the gas is maintained at a dew point corresponding to a temperature of −30° C. or lower (less than 0.20 grains moisture per cu.ft.). A certain amount of oxygen is always present on the surface of the punchings and the supporting members in the furnace, and this reacts with the hydrogen, forming water vapor. If insufficient quantities of gas are passed through the furnace, the proportion of moisture so created in the annealing chamber itself will be much higher than that of the entering gas, and the benefits of the dry gas will not be obtained.

After the soaking period has been completed, the metal is cooled at the desired rate by controlling the gas velocity.

The processing of hipernik has been given because it illustrates most of the features involved in the use of the plant equipment described. Both the melting equipment and the annealing department were originally built to meet the requirement for this material. Hipernik has been produced in substantial tonnage for a number of years.

Adaptability to New Alloys

The adaptability of the plant to the making of other metals with widely different critical features shows its inherent flexibility. By the use of small melting furnaces, experimental quantities of new alloys can be made economically yet under conditions approximating later manufacture on a larger scale. Similarly, a number of small annealing furnaces connected as desired to power and gas systems are used in giving special heat treatments to small quantities during the development stages of new products. Thus we have combined the needs of development operations with larger scale commercial production of technical materials. This helps to reduce the hazards encountered in bridging the inevitable gap between laboratory experiments on new materials and their production in quantity.

Birmingham was host to another openhearth conference, one of many held by members of the A. I. M. E. interested in steel making. Mutual problems of blast furnace operator and steel melter were discussed with the utmost frankness

Iron and Steel Producers Meet at Birmingham

By T. L. Joseph
Professor of Metallurgy
University of Minnesota

THE 20th National Openhearth Conference was held in Birmingham, Ala., early in April, in conjunction with meetings sponsored by the Blast Furnace and Raw Materials Committee of the American Institute of Mining and Metallurgical Engineers. A registration of 257 for the openhearth meetings and 150 for the blast furnace and raw materials sessions is a compliment to the men who arranged the excellent program, particularly the local committee which did much to make the meeting a success. The two groups met in parallel sessions, except for a joint one devoted to the effect of pig iron on the quality of steel. Many expressed the opinion that the meeting was one of the most successful of its kind ever held.

Birmingham, situated in a valley between two ranges of hills, offered an ideal setting for such a meeting. As an industrial site it is unique. All the raw materials required to produce iron and steel are available within a short radius. Red Mountain to the south contains large deposits of ore, the hills to the north contain the coal and the valley between is underlaid with limestone. While the geographical location of raw materials is almost ideal, the grade of ore and coal presents problems in mining and preparation. About four-fifths of the metallurgical coal is washed, compared to about one-fifth for Pennsylvania and one-eighth for West Virginia. The iron ore of Alabama contains 35 to 37% iron compared with an average of 51.5% iron for Lake Superior ores. Naturally this increases the expense of getting proper raw materials to the furnaces, and melting and handling large quantities of slag during the smelting.

Following the plan of previous meetings a list of prepared questions was discussed. Some of the questions were introduced with short papers but most of the time was devoted to informal discussions of refractories and furnace construction, quality of steel-making pig iron, steel quality, and metallurgical problems. The last session was devoted to safety and various details of openhearth practice. While few of the discussions pertained specifically to quality of product, important features of practice that govern ingot structure and surface and steel quality were covered.

Nature of "Immature" Slag

At the opening session G. D. Tranter, general superintendent of the American Rolling Mill Co., pointed out that the steel industry is changing rapidly and is searching constantly for closer control of the openhearth process and quality of product. He emphasized the need for super-refractories and for improve-

ment in the efficiency of heat transfer. Casting of steel into large ingots, necessary to produce large slabs and wide sheets, has magnified the difficult problem of segregation in the ingot. Reference was made to experiments now in progress on direct pouring of the steel on rolls — a procedure short circuiting the ingot, but one that presents operating difficulties yet to be solved.

In a discussion devoted largely to refractories, W. J. McCaughey of Ohio State University touched upon the important question of slag control. Improved methods of controlling the iron oxide in the slag are now recognized as one of the most important developments in openhearth practice. Iron oxide control gives closer regulation of the process and more satisfactory performance of the steel in the customer's plant.

Professor McCaughey's microscopic work shows that an immature slag may contain 25 to 30% of suspended particles not in solution in the slag. The concentration of iron oxides in such a slag is high, but it decreases when the undissolved particles such as di-calcium silicate go into solution. In a mature slag or a finishing slag the di-calcium silicate is in solution in a well dispersed system.

Ladling Off a Slag Scum From Steel Ingots in Openhearth Dept., Ford Motor Co.

It is well recognized that a more complete understanding of the openhearth slags is needed to deal quantitatively with the active iron oxide. In addition to knowing the compounds present in the solid slag, it will be more necessary to know something concerning the relative activity of the molten slag at steel making temperatures.

Better Pig Iron for Steel Makers

The joint session of the openhearth and blast furnace groups afforded an opportunity for openhearth operators to state the kind of iron they preferred and for the blast furnace operators to point out the difficulties which are likely to be encountered in the manufacture of such iron.

One openhearth operator specified that ideal pig iron should be 100° hotter than average temperature (or about 2700° F.) and that it should contain a maximum of 0.50% silicon, a maximum of 0.025% sulphur, about 2.0% manganese and no nitrogen. Another proposal was to place the upper limit for sulphur at 0.020% since sulphur can be removed more readily in the blast furnace than in the openhearth.

Blast furnace operators agreed that it would be difficult if not impossible to meet these specifications with present raw materials and equipment. However, impossible as these specifications for pig iron may appear to them, it is well known that sulphur control is very important in the production of deep drawing steel. With steel containing 0.020% sulphur the segregation of this element would be compara-

tively small, permitting a much lower sulphur content in the center of sheets rolled from the top slab of the ingots. However, in view of the difficulty and added cost of producing low sulphur iron in the blast furnace, the situation suggests a careful study of sulphur control in the openhearth, particularly as to the amount of sulphur in the finished steel that came from the hot metal charged, as compared with the amount absorbed from the fuel.

The most hopeful point discussed regarding the quality of pig iron was the importance of uniformity in analysis. It was brought out in the discussions that more satisfactory results are obtained when all the lime is supplied as raw lime in the initial charge. If the silicon in the iron varies widely it is difficult to determine the proper limestone charge. Since the FeO in the slag, and the sulphur distribution between slag and metal — both essential features of control — depend upon the basicity of the slag, the importance of holding the silicon uniform is readily understood. With varying silicon content the difficulty of avoiding soft heats was discussed. It appears that more attention and credit should be given for the production of iron of uniform analysis and that some uniformity index would constitute a better appraisal of quality than many much more obscure characteristics, such as the amount of oxides and gases present.

With reference to oxides in pig iron, your reporter presented data on the oxides in basic iron produced over a period of several months. While the iron contained unreduced oxides, there was no evidence that they persisted through the openhearth refining process. Oxides coming in with the iron do not tell the whole story, for comparatively large amounts of FeO are of course introduced into the steel bath to eliminate carbon. It is also true that silica as such (or as silicates) does not persist in the presence of large amounts of FeO. The introduction of FeO, the principal oxide in steel before the addition of deoxidizers, and its subsequent elimination are basic features of this strongly oxidizing process.

Points About Steel Making

The high price of scrap prompted a discussion of the use of higher percentages of hot metal in the openhearth. Foaming slags produced after hot metal additions are difficult to handle in stationary furnaces; they also retard heat transfer to the bath and prolong the heat. No satisfactory means was advanced for handling more than about 45% hot metal charges in stationary furnaces. It was brought out that plants equipped with converters and able to use the duplex process have an economic advantage at present high prices for scrap.

Recent improvements in openhearth practice were summarized as follows: Movable Rose ports, double burned dolomite, refractory lined hot-tops, control of FeO in slag, wider use of instruments and insulation, and controlled combustion.

R. C. Good of the Electro Metallurgical Sales Corp. discussed the effect of carbon, residual manganese, oxide content of the bath and the sulphur present upon the rimming action. He determines the optimum relation for the best rimming action from a curve which plots (% carbon + ¼% manganese) against the ratio (% oxides ÷ % sulphur). If other factors are constant, sulphur affects the rimming action. A decrease in sulphur requires an increase in manganese and aluminum. The best conditions are obtained by adjusting the additions of manganese and aluminum.

Sodium Fluoride as Medicine

The use of sodium fluoride was discussed as a means of controlling the rimming action in the ingot mold. Several operators stated that the addition of about 2 oz. per ton increased the rimming action, having an effect opposite to additions of aluminum. Several operators stated that fluoride additions are also useful when cold heats or steel difficult to rim must be handled. One operator, who has used this material to promote mechanical agitation, reported that the structure of the lower part of the ingot was improved. The blow holes were deeper seated, cleaner and comparatively small. Good results were reported on 0.11 to 0.16% carbon steel; it did not cause any segregation and created no problem from the angle of health and safety.

John Chipman of the American Rolling Mill Co. presented some studies of slag samples taken on heats of steel ranging from 0.04 to 0.08% carbon just before tap or the addition of spiegel. Curves were exhibited showing that basic slags favor desulphurization. (Basicity was expressed as the relation between the CaO plus MnO to the SiO_2 plus P_2O_5.) An increase in the basicity of the slag was accompanied by

an increase in the ratio of FeO in the slag to the oxygen in the metal. He stated that highly basic slags are always high in FeO but the oxygen in the metal varies less than the FeO in the slag. For a given total iron oxide, the available iron oxide in the slag decreases as the basicity increases.

Following two days of technical sessions, all those attending the meeting were guests of the Tennessee Coal and Iron Co. An interesting and instructive trip was made by a special train to the company's ore mines, blast furnaces and steel mills. Those who have never visited in the Birmingham district may be surprised to find such a perfect example of "integrated" industry, rivaling in modernity and efficiency that to be found in any of the more advertised American steel centers. A visit to this hospitable community will prove interesting and instructive and is highly to be recommended.

A Six-Ton Induction Furnace

By Herr Boer

Abstracted from Siemens Zeitschrift, 1936, p. 255

HIGH FREQUENCY induction furnaces were first put to commercial (as distinguished from experimental) work in Germany in 1928. These early ones had a capacity of 650 lb. to 1½ tons at most. In the meantime over a hundred of them have been installed, in keeping with their acknowledged metallurgical advantages. The largest built by Siemens & Halske is a six-ton unit, now in successful operation since early in 1936. Eight-ton furnaces are under consideration; the development has by no means ended.

The power plant is of importance. For this furnace a motor-generator set delivers 1600 kilowatts of 500-cycle current; the power remains constant even though voltages may range from 2300 to 3000. This wide voltage range is due to changes of the electrical conditions during the melt-down, such as different demands when melting of magnetic materials such as nickel or iron, the change of resistance with temperature as the metal melts and is superheated, and also the increase of the "degree of coupling" between furnace coil and bath with a crucible whose wall has been thinned by washing. [The electrical circuits and their safe and accurate control are described in detail in the original.]

The furnace coil consists of a rectangular copper tube with 0.31-in. wall thickness, bent into a self-contained, rigid helix without bracing. To insure proper spacing of the turns, "combs" made of linax [asbestos or fiber composition] are fixed in sockets made of the same material. These members also act as vertical struts, spaced equally around the body. Copper pieces are soldered to the top and bottom turn and these are screwed to the comb sockets. Slabs of cemented slate and asbestos form the bottom and top; they carry compressive stresses only, since they are not expected to hold together the coil.

Current enters the furnace coil through knife switches which are disconnected prior to tilting the furnace. An interlocking device prevents movement of the furnace while the switches are closed, or opening of the switches while the current is on.

The dimensions of the furnace box are so ample that the stray lines of the electromagnetic field do not cause appreciable heating of the frame. The furnace coil is located in the frame near the side from which the charge is poured, resting on firebricks directly over supporting beams. The reason for locating the coil at one side of the furnace box is to shorten the length of the stream when pouring; the metallurgical reason is principally that this prevents cooling and undue oxidation. The front supporting beams (near the coil) are made of non-magnetic steel to minimize leakage losses. They are fastened to a sectional framework with insulators so that there are no closed electrical circuits in the frame, and the entire frame is grounded to protect attendants.

This type of box-like skeleton construction has certain advantages over a tall furnace — tall in comparison with the diameter — in which the stray outside field of the furnace coil must be screened out with a copper cylinder. The power consumption is lower than with tall furnaces; the furnace coil, being exposed, can be observed constantly and possible dangers may be recognized in time. Above all, the accessibility of the furnace coil, and hence the outside of the crucible, with this large furnace, has been found highly valuable. *(Continued on page 660)*

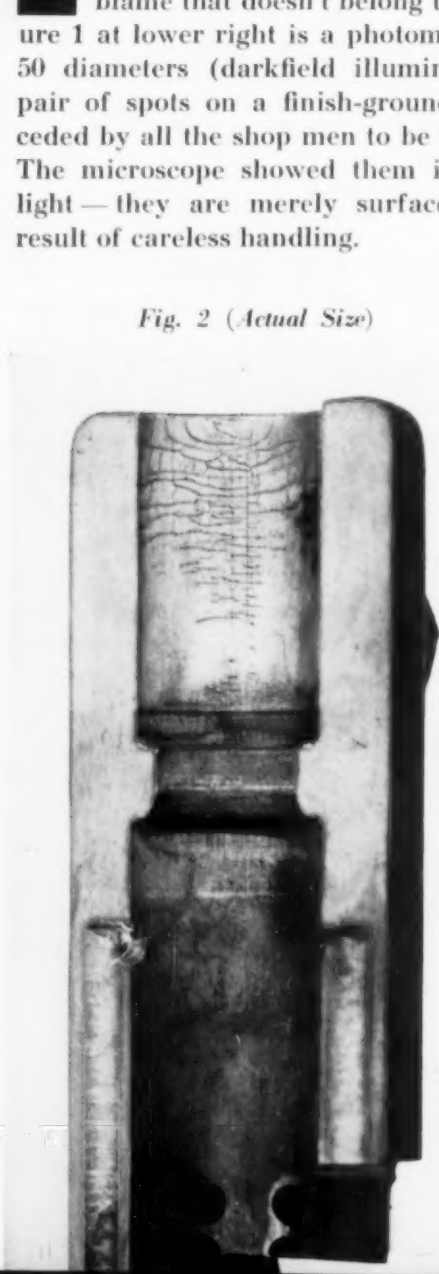
This is the second of a series on "Diagnosis of Metal Troubles in Industry" by R. S. Archer, J. L. Burns and V. Brown of the Republic Steel Corporation's Metallurgical Department in the Chicago District. Several defects arising from forging practice were illustrated in the April issue

Troubles Due to Grinding or Machining

Inclusions

INCLUSIONS in the metal get a lot of blame that doesn't belong to them. Figure 1 at lower right is a photomicrograph at 50 diameters (darkfield illumination) of a pair of spots on a finish-ground shaft conceded by all the shop men to be "inclusions." The microscope showed them in their true light — they are merely surface nicks, the result of careless handling.

Fig. 2 (Actual Size)

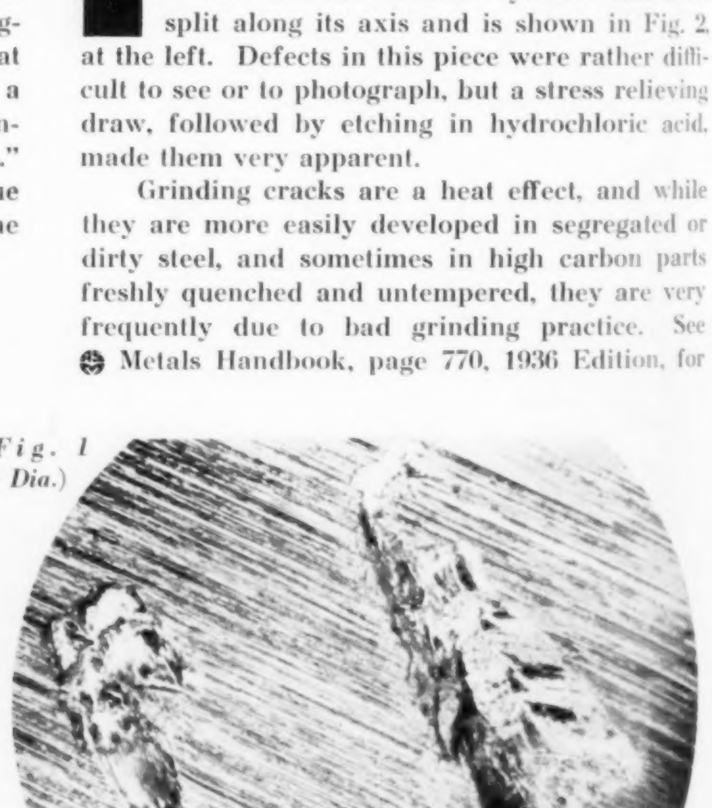


Grinding Cracks

A DEFECTIVE air hammer cylinder has been split along its axis and is shown in Fig. 2, at the left. Defects in this piece were rather difficult to see or to photograph, but a stress relieving draw, followed by etching in hydrochloric acid, made them very apparent.

Grinding cracks are a heat effect, and while they are more easily developed in segregated or dirty steel, and sometimes in high carbon parts freshly quenched and untempered, they are very frequently due to bad grinding practice. See Ⓐ Metals Handbook, page 770, 1936 Edition, for

Fig. 1 (30 Dia.)



suggested remedies for this type of trouble.

(A surprising amount of heat may be developed at a ground surface, as is proved by the views on these pages. Hot metal in a spot on a rigid surface can only expand outwardly, and the resulting bulge is immediately leveled off by the wheel, leaving the rest of the heated metal upset. This metal later cools and shrinks, and since there is not enough metal to fill the original volume, that which remains is badly stretched laterally.—Ed.)

Heating During Finish Grinding on a Wet Wheel

THE VERY HIGH surface temperatures that can be produced by grinding operations, even including wet grinding, are not always appreciated. Figure 3 shows a section through a valve tappet made of screw stock (high sulphur, low carbon steel) carburized and hardened. Inspectors had reported the surface of the tappet to be "spotty" in hardness by the Rockwell test, although it seemed uniformly hard to a file. Figure 3 shows the reason for this. There is a skin of file-hard martensite too thin to resist the crushing indentation of the Rockwell test. Figure 4 shows the surface layer at higher magnification. Approximately the entire right-hand half of the field, including the dark-etching and the white martensitic skin, was originally martensitic. After carburizing and hardening, this tappet was ground wet on the side of the grinding wheel and, in spite of a good flow of cooling water, the surface was reheated by the grinding operations above the critical temperature. It was then re-hardened, either by the quenching action of the water, or by conduction of heat to the cold interior. Meanwhile, however, the metal immediately back of this re-hardened skin was heated high enough to be tempered to a structure of such low hardness that it would not support the Rockwell impression shown in Fig. 3.

Figure 5, at still higher magnification, shows the hard martensitic skin in more detail, and a grinding crack extending nearly through it.

Fig. 3 (50 Diameters)

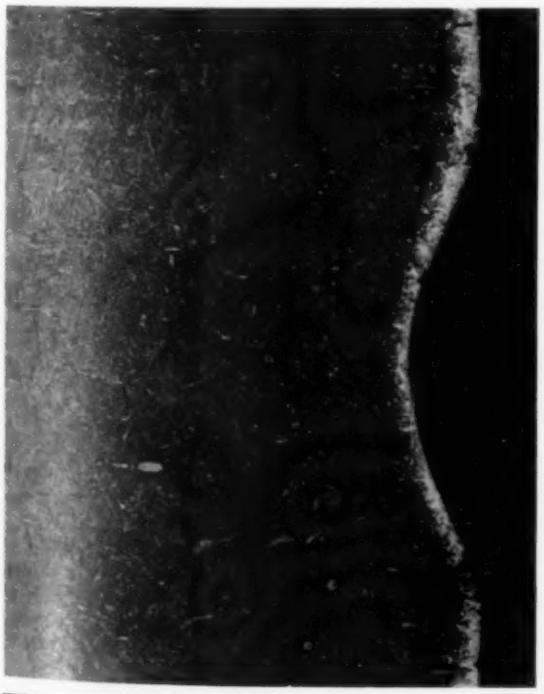
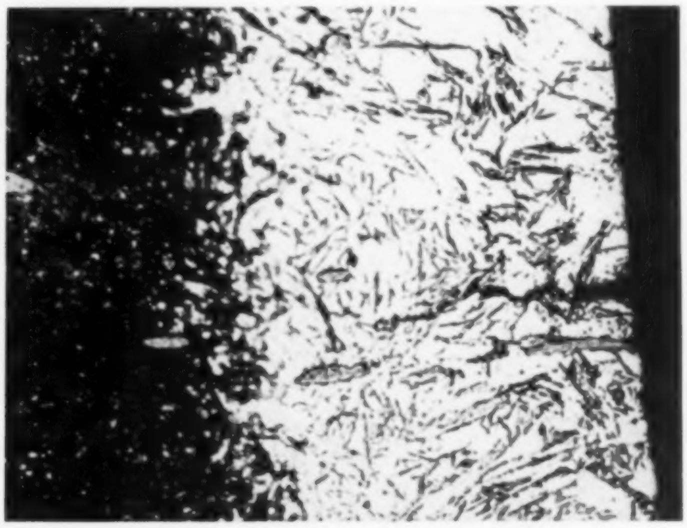


Fig. 4, Above, at 100 Diameters;

Fig. 5, Below, at 500 Diameters



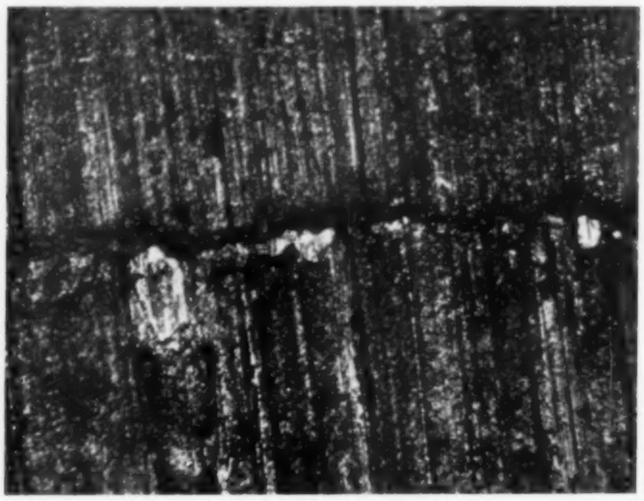


Fig. 6 (50 Diameters)

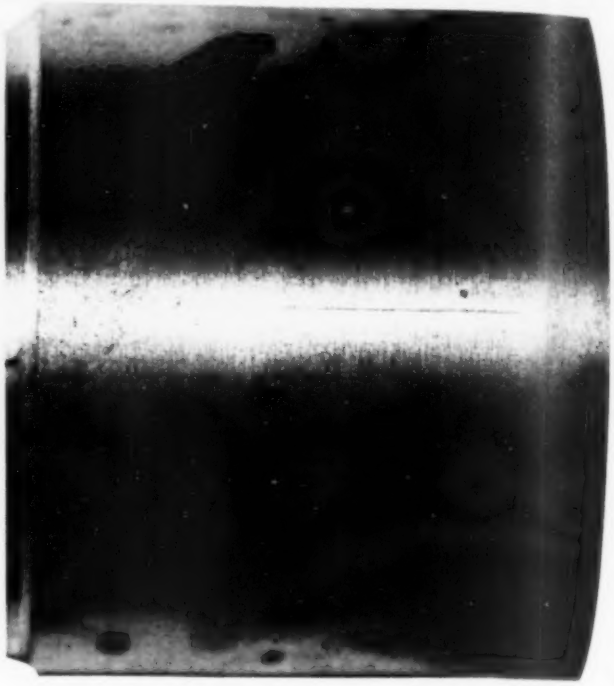


Fig. 7 (Twice Size)

Two Causes of "Hairline Seams"

When so-called hairline seams appear on a machined surface, they are usually blamed on non-metallic inclusions in the steel. This may or may not be true. The defects shown in the upper views (Fig. 6 and 7) are due to this cause; Fig. 7 at 2 diameters shows a good example of a hairline seam on the highly illuminated part of the round; Fig. 6 of the unpolished surface at 50 diameters shows a number of inclusions in a substantially straight line.

The lower pair of views, however, show a surface marking of generally similar appearance, which might easily be mistaken for a hairline seam of the same type as that shown in Fig. 6 and 7. Figure 9, at higher magnification, shows that this mark is of a different character. It was actually caused by the directional properties of the steel (ferrite banding, for example), which happened to be a grade which rather frequently exhibits this condition.

(Sometimes hairline cracks have been blamed on very small contraction cavities in the ingot, not welded shut during hot working. Unless they occur in highly stressed regions in vital parts, they are probably harmless, as it is certain that numberless parts, afflicted with them but undetected on inspection, have given satisfactory service. — Ed.)

Fig. 8 (Twice Size)

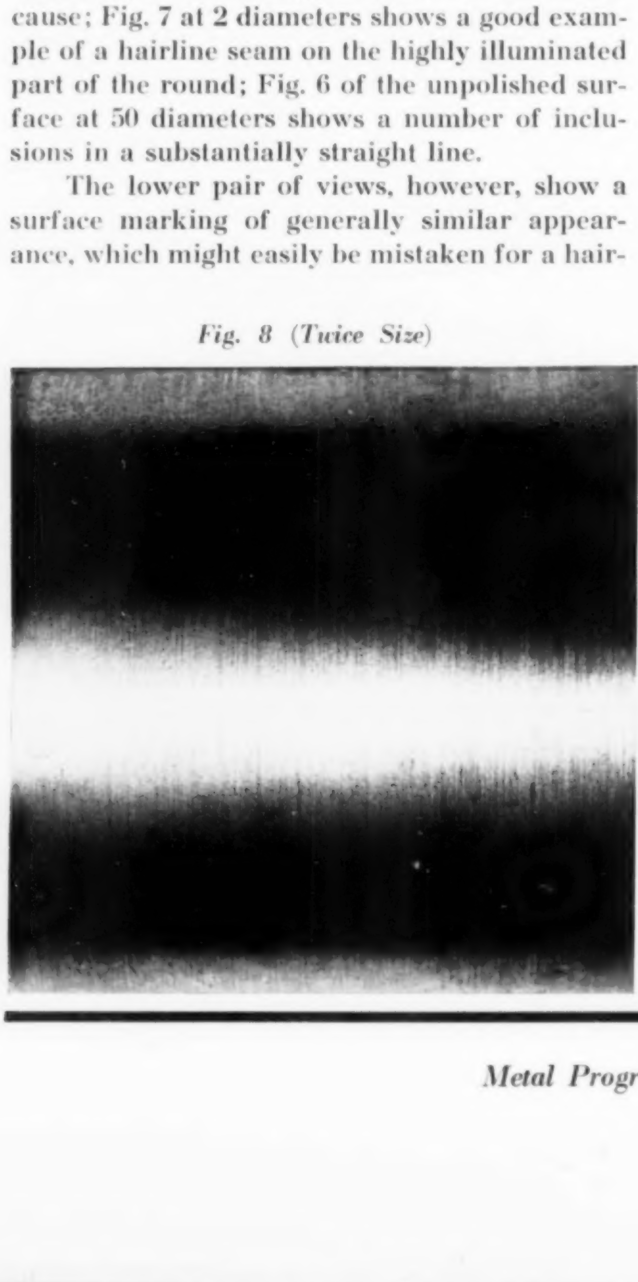
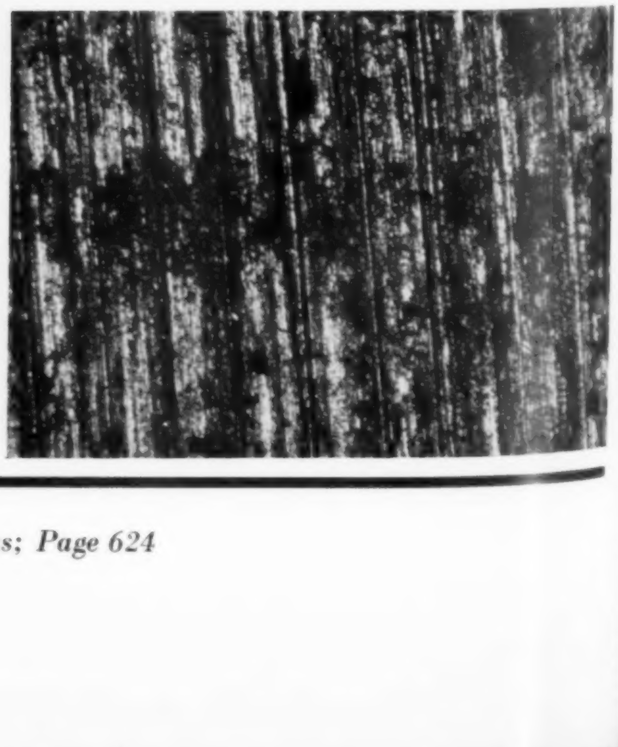


Fig. 9 (50 Diameters)



A Hard Spot

A MACHINE PART was broken on a Fellows gear shaper during a production run, and it was suspected that breakdown was caused by an inclusion or some other defect in the gear which was being shaped at the time. Examination of the gear showed, however, that the suspected hard spots were not something which had been put there unintentionally by the steel melter or the heat treating department, but were small particles of high speed steel! Tracing this gear back in its history in the machine shop, it was found that some of the corners of the teeth on the hob that had worked on it were broken off; evidently some of these fragments had become imbedded in the gear. The trouble in the shaping operation, therefore, had nothing to do with shaping or the part being shaped, but resulted from trouble in the preceding hobbing operation, not noticed at the time.

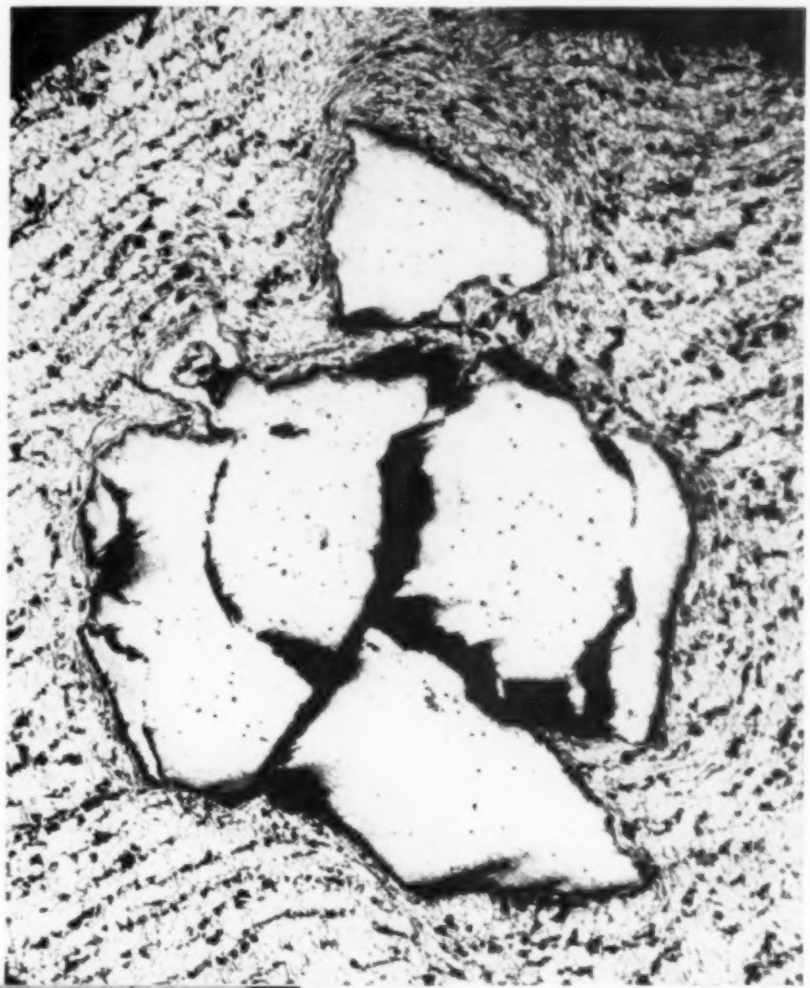


Fig. 10 (Above). A section just below the surface of a partly machined gear of S.A.E. 3120 steel, with embedded foreign particles. Etched with nital to bring out the structure of the alloy steel, and magnified 50 dia.

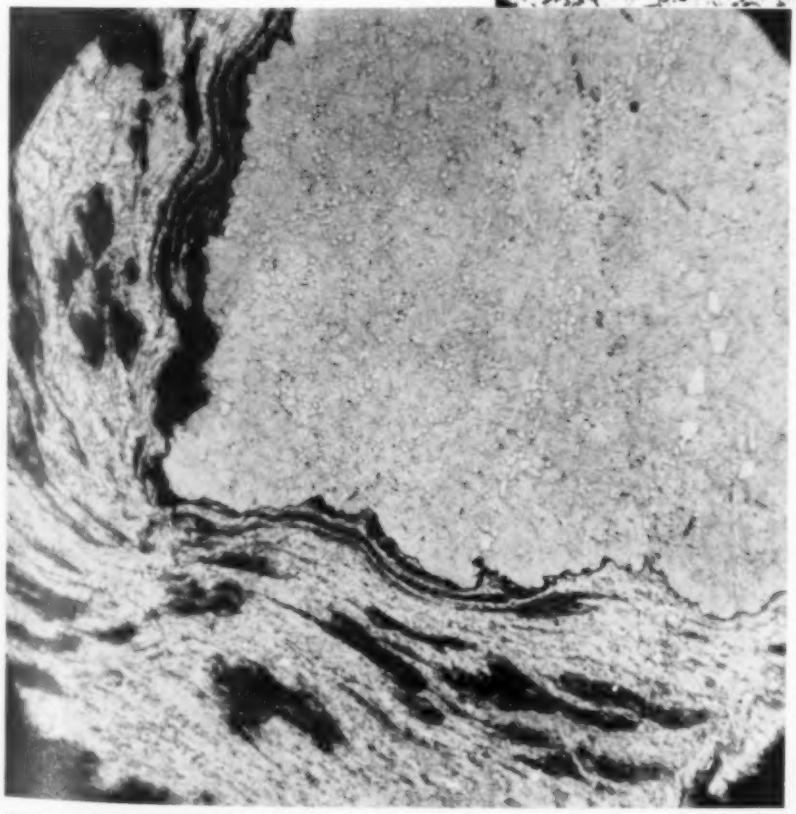


Fig. 11 (at Left). The same sample was then etched more deeply to bring out the structure in the inclusion and it was clearly revealed as a fragment of a high speed cutter. Note the intensely cold-worked structure in the metal of the gear immediately surrounding this embedded fragment

Relation Between Tool Set-Up and Machinability

The relative machinability of different types of steel is often rated upon the basis of shop tests, which are supposed to be very practical in nature. That the results may be quite misleading is shown in the photographs on this page.

Two types of steel are involved in this test. Both are standard S.A.E. analyses, and are designated as Type A and Type B. Both are in the cold-drawn condition, and all of the specimens of Type B are from the same bar.

Satisfactory practice as to tool dimensions, speeds and feeds had been established for machining Type A to produce economically the finish shown in Fig. 12, rated as satisfactory for the purpose intended. With the same tools and machining conditions, a very poor finish resulted on Type B (Fig. 13).

Figure 14 shows the results on Type B of using the same cutting tool but reground with a different contour. This is immeasurably better, but still capable of improvement, as is shown in Fig. 15, where a tool of entirely different shape was used (as indicated by the square shoulder at the bottom end of the cut).

It is rather clear that on the basis of the first tooling, Type A is far better than Type B, but on the basis of the revised tooling, Type B gives, if anything, a better surface than Type A. (It should be noted that the same feed and speed were used throughout, and all photos are actual size.)

Fig. 12 (at Extreme Left). Satisfactory finish on parts from screw machine, cut from a cold-drawn alloy steel of Type A. All these views are actual size

Fig. 13. Using the same tools, feeds and speeds, a very rough, gouged surface was produced on cold-drawn steel (another alloy) of Type B

Fig. 14. By merely regrinding the tools to a slightly different contour, a great improvement resulted. All the samples of steel B were cut from the same bar

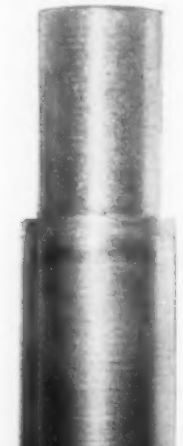


Fig. 15. Using tools of entirely different shape, but maintaining speeds and feeds, an even better surface finish was gotten on Type B than on the original stock, Type A

The Embrittlement of Solid Copper Containing Oxygen in Hot Reducing Atmospheres

THE EMBRITTLEMENT of tough pitch copper (which ordinarily contains from 0.03 to 0.07% oxygen) in reducing atmospheres, at temperatures of 950° F. and 500° C. and above, is a subject about which much has been written. It is well understood by a few, and yet is one that is often forgotten by others, judging from the frequency with which problems involving it arise.

It is well known that hydrogen at these temperatures diffuses through solid copper at a definite rate, and that such hydrogen coming in contact with cuprous oxide in the solid copper reduces that oxide, forming steam as one of the products of the reaction. It was pointed out by Pilling in 1919 that the diffusion rate of the steam is very much less than that of the hydrogen, and a pressure due to the accumulation of the former is quickly built up, causing voids at the grain boundaries of the metal.

When tough pitch copper is heated in an atmosphere of carbon monoxide, a similar sequence of events takes place. The diffusion rate of carbon monoxide through solid copper being considerably greater than that of the carbon dioxide, which is formed by the reaction of carbon monoxide on cuprous oxide, grain boundary voids are formed due to the accumulated pressure of carbon dioxide, such voids being similar to those formed by the accumulation of steam in the reaction between hydrogen and cuprous oxide.

As remarked at the outset, these facts are so well known that it is unlikely that anyone skilled in the art would consider heating tough pitch copper in either hydrogen or carbon monoxide. Evidence, however, points to the fact that many of us who should know, do not realize what a *small* amount of reducing gas is required to cause embrittlement, although this phase of the subject has been repeatedly stressed in the literature.

By T. S. Fuller
Research Laboratory
General Electric Co.
Schenectady, N. Y.

Experiments performed by the author and reported in 1922 served to emphasize this point, and are therefore worthy of restatement. Tough pitch copper was packed in clean sea sand in a seamless steel tube and was heated to a temperature of 800° C. (1475° F.) for one hour in an electrically heated furnace. The ends of the tube were closed with iron plugs. The sample of copper, on being removed from the tube after cooling to room temperature, was found to be extremely brittle. Microscopic examination showed the open grain boundaries so characteristic of copper in the "gassed" condition.

This result was so unexpected that the question naturally arising was, what is the constituent associated with iron pipe or clean sea sand which is responsible for a reducing atmosphere when heated? Two thoughts presented themselves; first, the carbon present to the extent of 0.2% in the iron pipe possibly would be sufficient to generate enough carbon monoxide to cause the embrittlement; and second, organic matter on the surface of the sea sand might be present in sufficient quantity when heated to cause a limited amount of reducing gas, probably carbon monoxide. Either or both might be responsible.

Accordingly, a sample of tough pitch wire from the same lot of copper previously used was packed in finely divided aluminum oxide in a porcelain tube and heated for one hour at 800° C. Wire, so treated, at the end of the experiment was ductile and showed no evidence under the microscope *(Continued on page 658)*

William Roy Chapin

ALBERT SAUVEUR ACHIEVEMENT AWARD FOR 1936

WILLIAM ROY CHAPIN

"For his fundamental work in connection with two-stage quenching of steel, which has explained many mysteries of heat treatment results, has stimulated and guided many important researches, and has led to the clarification of theory and improvement in practice of steel treating."

This was the citation on the award to Bill Chapin of the Albert Sauveur Achievement Medal at the last ⊛ convention. Men come and men go, both great and small. Some men are born to be great, some are thought to be great because their fellow men elect them to be so. But the greatest of the great are those who recognize the plight of their fellows, who in their daily work strive to lighten the burden and smooth the path down which mankind must travel, and who in both their waking and sleeping hours are working toward a better method of doing things.

To this last class is elected our fellow metallurgist, William Roy Chapin.

He is a down east Yankee, born in the state of Vermont on February 4, 1881, with a native wit as keen as a northeaster and a mind as strong as the rock-bound coast of New England.

As a boy his parents took him to Florence, Alabama, where he attended school, graduating from the State Normal College in Florence and later attending the University of Alabama. Metals in their various manifestations always fascinated him — especially steel and its ability to be either soft and ductile or hard and brittle.

So we soon find him getting a start as chemist for the Tennessee Coal and Iron Co. Later he transferred to the Cleveland Twist Drill Co., where he was in charge of the heat treating department. After a successful period spent in this capacity Chapin became chief metallurgist in charge of tests and research at the E. C. Atkins & Co., Indianapolis, Ind., manufacturers of saws and machine knives. Thus he had reached the peak of his profession in a plant where he had to do with fine cutting tools and tools to make tools.

It must be remembered that this was before the day of the science of heat treating. The art, thousands of years old, had been confined almost entirely to the hardening of tools and weapons. Chapin immediately started inquiring into the reasons behind many of the traditions of his art, and was one of the first to realize the foolishness of locking his information behind sealed lips. He was in debt to countless forgotten experimenters back through the ages. He would repay that debt if he could. So the world began to beat a path to his door where the latch string was always out!

Being a metallurgist in the capacity which he enjoys, he has been brought in close contact with all types of steel that are to be fabricated into finished articles of commerce. The knowledge gained along these lines has always been shared freely with any who seek it. He is always ready for the tasks that confront him, always on the lookout for better methods, always willing to help and advise, tireless in his work and practical in his viewpoint at all times. A thorough questioner. Anyone placing before him a result of a particular research or investigation must be prepared to know that subject thoroughly. The most minute detail does not escape.

Bill Chapin is an engaging speaker. His New England tradition and Hoosier surroundings have fostered a keen interest in political problems. This comes frequently to the surface in witty or penetrating flashes in his day-by-day conversations and in his discussions of serious technical matters.

It was after arriving in Indianapolis that he met and married Stella G. Harman. They have two children, William R., Jr., and Dorothy. He is an ardent golf and bowling enthusiast whose motto, when a little wager is up, is "Keep the money in the laboratory!" He is also president of his own company, the W. R. Chapin Co., manufacturing Cinch Steel Cement.

Mr. Chapin's pioneering work, published in *Transactions* of the American Society for Steel Treating in 1922, determined the fact experimentally that austenite transforms into martensite not at temperatures a little below the critical, as was ordinarily supposed, but at 300° F. or less. Some cooling curves made three years earlier in France by Portevin and Garvin had indicated the presence of a delayed transformation in quenched carbon steel, but all three experimenters were far ahead of their time in getting at the essence of the actions when hot steel is quenched. In America, at least, a reasonably clear exposition of this mechanism was not given until 1930, when H. J. French summarized several years of experimentation on quenching rates at the Bureau of Standards, and Davenport and Bain presented their studies on transformation at subcritical temperatures

made at the United States Steel Corp. Research Laboratory.

As Dr. Jeffries pointed out in reading the citation of the Sauveur Award, the French investigation was long and brilliant, made with specialized apparatus and technique never excelled. Chapin, on the other hand, made his additional discoveries with the common tools available in all metallurgical laboratories. That others of us did not carry on until years thereafter is yet another proof that a people seldom recognizes its truly great contemporaries.

Properties of Some Steels in the Hardening Range

By W. R. Chapin

A paper presented before the Cleveland Chapter. Reprinted from Transactions, American Society for Steel Treating, Vol. II, p. 507 (March, 1922)

In this paper the term "hardening range" is to mean that temperature range within which quenched steel acquires its maximum hardness as tested with the Brinell machine, scleroscope or file. This report applies only to those steels which, when properly quenched, harden throughout the mass, or as it may be expressed, harden "solid" and are martensitic when so hardened.

It is not claimed that this maximum hardness is the greatest hardness possible to obtain in these steels for it is well known that an even greater hardness is made possible by the use of certain quenching mediums and certain high temperatures. The maximum hardness referred to is the greatest hardness obtainable by the employment of commonly used quenching oil or plain water, the quenching temperatures being such as are used in good common practice.

	Test 1	Test 2	Test 3
Annealed, length	4.438 in.	3.968 in.	4.993 in.
Brinell	192	179	231
In hardening range, length	4.429 in.	3.973 in.	4.980 in.
Brinell	192	262	192
Cold, length	4.440 in.	3.978 in.	4.996 in.
Brinell	652	652	652

By reference to Test No. 1 it will be noted that this specimen, which was ½ in. square, was 192 Brinell in the annealed condition. The specimen was quenched in oil from a temperature of 1475° F. and taken from the oil while in the hardening range.

(It will be appreciated readily that the temperature of the piece when taken from the oil is difficult to measure accurately, particularly near the surface. It may be stated, however, from a great many tests removed from the bath in the hardening range and quickly polished for Brinell testing, that the color appearing on the polished surface would indicate strongly that this temperature lies between 400 and 500° F. It is respectfully suggested to those who have sufficiently delicate apparatus and the inclination that this hardening range temperature may be accurately plotted pyrometrically. This may be done by placing a sensitive couple in the center of a piece, protecting the couple by means of a copper tube brazed into the piece and attaching the couple to a sensitive instrument which will record rapid temperature changes.)

Specimen No. 1, it will be noted, was also 192 Brinell in the hardening range, practically file-hard, and could be readily deformed. It shrank 0.009 in. in the hardening range and in cooling in the hardening range naturally in the air to the cold (by which is meant room temperature) it expanded 0.011 in. and was 652 Brinell when cold. It will be noted that it expanded only 0.002 in. from the annealed to the cold state. Test No. 1 is a well known oil hardening steel, a so-called "non-shrinking" steel, but as a matter of fact the steel did shrink 0.009 in. in the hardening range and then expanded 0.011 in. below that range.

It is to be noted particularly that Specimen No. 1 was entirely unaffected by a powerful horseshoe magnet in the hardening range. This fact was first observed by the writer's assistant, W. L. Appel. It is to be noted that this loss of magnetism in the hardening range is most noticeable immediately after withdrawing from the quenching bath and further that there is a gradual return of the magnetic property as the steel cools through the hardening range to the cold. It is also interesting to note that with the gradual return of the magnetic property the Brinell hardness also gradually rises.

The appearance of the Brinell indentation in the hardening range is peculiar in that it is not clear cut but there is a rounding off entirely around the periphery. This appearance is characteristic of all the steels tested in the hardening range.

Referring to Test No. 3 it will be seen that this specimen also shrank in the hardening range and showed even a lower Brinell than in the annealed state. Test No. 3 was also non-magnetic in that range, could be readily deformed and was practically file-hard. It also expanded from the hardening range to the cold and was 652 Brinell when cold. This specimen was a round disk 0.156 in. thick, quenched in oil from 1500° F. and removed from the bath while in the hardening range.

In order to determine the Brinell hardness of Tests No. 1 and 3 in the center of the bar, other samples from the same bars were quenched and brought out in the hardening range, broken and Brinell tested in the center. These pieces were 192 Brinell in the center, practically file-hard in the center and were 652 when cold. This test was made repeatedly with the same result each time.

Attention is called to Test No. 2, which is a well known water hardening steel. The sample was ½ in. square, quenched in water from 1440° F. and removed from the bath while in the hardening range. It will be noted that No. 2 expanded continually in the hardening range until cold and was magnetic in that range.

Test No. 14 — This specimen, 5.540x0.75x0.050 in., was quenched from 1500° F. in oil. It was removed from the oil while in the hardening range and proved to be non-magnetic. Its changes in size, as shown in the following, are in the same proportion as a so-called oil hardening steel.

	Length
Annealed	5.5400
In hardening range	5.5315
Cold	5.5465

It will be seen from the table of chemical composition that this also is an ordinary water hardening tool steel. This steel when quenched in water, as in common practice, is magnetic in the hardening range and expands continually until cold. A specimen cut from Bar No. 14 failed to harden in oil in the original size (which was ¾ in. wide by 3/16 in. thick) but hardened very readily in water. When Bar No. 14 was machined down to 0.050 in. thick, it will be seen that it hardened in oil readily and exhibited all the characteristics of a true oil hardening steel, that is, in the hardening range it first shrank, then expanded, showed a low Brinell gradually increasing, and was non-magnetic. On the other hand, a piece from Bar No. 1 when quenched in water and brought out in the hardening range was distinctly magnetic, was file-hard, showed a low Brinell and acquired maximum Brinell when cold.

	Test No. 12		Test No. 13	
	Length	Width	Length	Width
Annealed	60.286	4.694	60.396	6.000
Oil quenched from 1500° F. In hardening range	60.091	4.684	60.203	5.987
Cold	60.323	4.696	60.422	6.004
Drawn at 800° F.	60.087	4.690	60.294	6.000

Tests No. 12 and 13 are average specimens from 100 tests. They are very interesting in that they show that in the hardening range these steels shrank in every dimension and then expanded in every dimension as they approached the cold. Furthermore these steels shrank upon drawing. Test No. 12 in the hardening range first shrank 0.195 in. in length and 0.010 in. in width and then expanded 0.232 in. in length and 0.012 in. in width. Upon drawing at a temperature of 800° F., test No. 12 then shrank 0.236 in. in length and 0.006 in. in width.

Chemical Analyses of Test Specimens

Steels	Test No.	C	Mn	Si	S	P	Cr	V	Ni
A	1	0.770	1.48	0.407	0.021	0.006	0.06	0.19	—
B	2,6,7,10,11	1.070	0.28	0.404	0.022	0.010	—	—	—
C	3	0.800	0.35	0.200	0.020	0.020	0.40	—	1.25
D	4,5,8,9	0.890	0.43	0.162	0.018	0.025	0.78	—	1.56
E	12	0.780	0.39	0.146	0.014	0.023	0.32	—	1.36
F	13	1.044	0.48	0.118	0.034	0.010	0.50	—	1.37
G	14	1.112	0.29	0.192	0.023	0.016	—	—	—

Specimen No. 12 was 0.100 in. thick and No. 13 was 0.090 in. thick. The change of thickness in the hardening range is not reported on account of the difficulty in getting an accurate measurement on account of rolling scale coming off and on account of getting an accurate record of such a small change as would take place in the thickness. But since these 100 pieces shrank in two dimensions and then expanded in two dimensions it is perfectly logical to expect that they also contracted and then expanded in the third dimension. The 100 specimens were non-magnetic in the hardening range.

Another specimen from No. 12 and No. 13 was given the same treatment and after being drawn to 800° F. was annealed to produce a pearlitic structure. The measurements were then found to be practically the same as originally.

By reference to Tests No. 4 to 11 inclusive, it will be seen that the rate of cooling from the hardening range to the cold does not affect the ultimate hardness when cold. A piece from Bar No. 1 was quenched in oil and was allowed to cool from the hardening range to the cold in a patented compound requiring an hour to cool. It was 192 Brinell in the

hardening range and 652 Brinell when cold. It is apparently true moreover that there is less distortion and less ultimate change of volume if these steels are allowed to cool slowly from the hardening range to the cold than when allowed to cool in the quenching bath, as in common practice.

	Test No. 4		Test No. 5	
	Brinell	Filed	Brinell	Filed
Quenched	652		192	
Quenched and drawn	652	slightly	652	slightly
Redrawn	627	easily	627	easily

It is to be noted that Specimen No. 4 was quenched in oil from 1500° F. until cold and then drawn at 400° F. in oil for 15 min. After drawing it was allowed to cool in the air and was 652 Brinell both before drawing and after drawing. After drawing it could be filed slightly. It was then drawn again for 15 min. at 400° F. in oil and when cold was then 627 Brinell and could be filed easily.

Test No. 5 was quenched in oil from 1500° F. the same as No. 4 but taken out in the hardening range and drawn at once at 400° F. in oil for 15 min. It will be seen that No. 5 was 192 Brinell in the hardening range and was non-magnetic. After drawing 15 min. it was 652 Brinell and could be filed slightly. Test No. 5 was then drawn 15 min. more at 400° F. in oil and was then 627 Brinell and could be filed easily.

	Test No. 6		Test No. 7	
	Length	Hardness	Length	Hardness
Annealed	4.146	179	4.171	179
Quenched	4.159	683	—	302
Drawn	4.155	627	4.176	627

By referring to No. 6 (a ½-in. square specimen) it will be noted that it Brinell tested 179 in the annealed state and upon quenching in water from 1440° F. until cold it expanded 0.013 in. in length and was 683 Brinell when cold. After drawing 15 min. in oil at 400° F. it contracted 0.004 in. in length and was 627 Brinell.

It will be seen that No. 7, quenched the same as No. 6 but taken out in the hardening range, was 302 Brinell in that range, was magnetic and was practically file-hard. Test No. 7 was drawn at once for 15 min. in oil at 400° F.; it was then 627 Brinell and could be filed readily. It will be noted that No. 7, which was cut from the same bar as No. 6, expanded 0.005 in. from the annealed to the cold state whereas No. 6 quenched regularly expanded 0.009 in. from the annealed to the cold.

	Test 8	Test 9	Test 10	Test 11
Quenched	652	192	683	321
Drawn	652	652	683	683

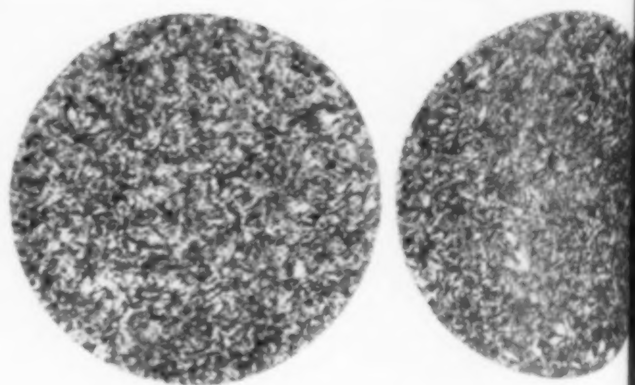
Referring to Test No. 8 it will be seen that after quenching regularly (to cold) in oil from 1500° F. and then drawing in oil for 15 min. at 350° F., a piece was 652 Brinell before and after drawing and after drawing was file-hard. Test No. 9 quenched the same way as No. 8 except taken out in the hardening range and drawn at once in oil for 15 min. at 350° F., was 192 Brinell in the hardening range and was non-magnetic. After drawing No. 9 was 652 Brinell and file-hard.

Test No. 10, when hardened regularly in water from a temperature of 1440° F. and then drawn at 250° F. in oil for 15 min., was 683 Brinell before and after drawing and was file-hard after drawing. Test No. 11 was quenched the same as No. 10 except it was taken out in the hardening range and drawn at once to 250° F. in oil for 15 min. It was 321 Brinell in the hardening range and was magnetic. After drawing No. 11 was 683 Brinell and file-hard.

By comparing No. 6 and 7 with No. 10 and 11 it will be seen readily that a drawing temperature of 400° F. was too high for this particular steel, for the reason that the martensite was decomposed at this temperature and consequently the piece could be filed readily, whereas No. 10 and 11, which were drawn at 250° F., were file-hard after drawing. Comparing No. 4 and 5 with No. 8 and 9 it is seen that 400° F. is too high for the drawing of this steel for the same reason, whereas 350° F. leaves the pieces file-hard after drawing.

It seems almost paradoxical that these steels exhibit in the hardening range a low Brinell and at the same time are practically file-hard and can be deformed readily. Similar observations have been made on a variety of other steels which harden solid in oil — such steels containing **(a)** about 1.00% tungsten, **(b)** chromium and tungsten, **(c)** chromium, vanadium and tungsten, **(d)** chromium, and **(e)** chromium and vanadium. Data are being prepared on high speed steel.

The foregoing tests indicate that all steels, and perhaps high speed steel, when quenched and hardened solid, first shrink and then expand. The non-magnetic properties of water hardening steels in



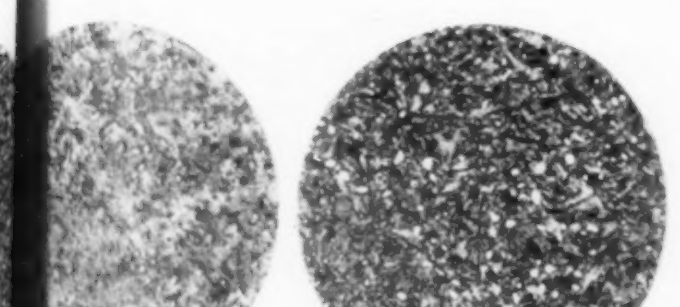
Steel No. 1, Oil Quenched From 1475° F. 1000 X Left: Steel was quenched cold and drawn 15 min. at 350° F. Right: Steel was withdrawn in hardening range and drawn immediately at 350° F. (15 min.). A much more uniform martensitic structure results

the hardening range are difficult to determine because of the rapidity of quenching, but by reference to Test No. 14 it is noted that when a water hardening steel hardens solid in oil it exhibits the characteristic hardening range properties of a regular oil hardened steel and vice versa. It can be shown that an oil hardening steel like No. 1 or 3 when quenched in water has the characteristic properties of a water hardening steel. Therefore, it is logical to assume, and it may even be demonstrated, that all steels whether oil or water hardening, which harden solid when quenched, are at some stage of the hardening range non-magnetic.

Since the steels in this paper that are of the oil hardening type (and also No. 14) are non-magnetic in the hardening range, and since it is the theory held by many that all steels above the Ac range contain gamma iron, and since it is well known that steels above the Ac range are non-magnetic, it naturally follows that the steels in this report contain gamma iron in the hardening range, and are therefore austenitic in that range.

Since, in order to harden, a steel must pass through the Ar range, it follows that these steels have not passed through the Ar range when taken from the oil in the hardening range, but the Ar range has been suppressed to a temperature approximating 400 to 500° F.

A further deduction is that, in the hardening range, austenite occupies a smaller volume and has a higher specific gravity than martensite. This deduction as to the specific gravity of the microconstituents is based entirely on the observations of the change of volume of the steels as noted in these tests and is therefore only a tentative deduction. It may well be proved that these changes of volume are not alone due to the formation of the different microconstituents but also to intermolecular change on account of the change in temperature.



Steel No. 2. Water Quenched From 1440° F. 1000 X Left: Steel was quenched cold and drawn 15 min. at 250° F. Right: Steel was withdrawn in hardening range and drawn immediately at 250° F. (15 min.). A much more uniform martensitic structure results

The writer does not seek to propound theories in this paper but merely wishes to draw attention to certain observations. It is earnestly hoped that these observations may draw from other metallurgists more and clearer reports and deductions.

It would seem safe to say that the practical value of this investigation is that it indicates certain possibilities. It is perfectly apparent from the tests that when a steel which hardens solid is quenched it first contracts and then expands in the hardening range. Since this expansion begins and is most rapid at the thinnest section and in the region farthest from the center of the steel it naturally follows that any quenched steel, such as punches, dies or cutters, should be withdrawn from the quenching medium in the hardening range and placed at once in a medium sufficiently hot to permit the martensite to form slowly and completely and uniformly but not hot enough to start the decomposition of the martensite into troostite or sorbite.

It may be stated as a truth that a steel properly treated in the hardening range, providing of course that the steel is of the correct analysis and has been made right, will be less liable to rupture and will show a minimum of deformation.

Photomicrographs of both oil hardening and water hardening steels will illustrate this point. Those that were withdrawn in the hardening range and tempered immediately show a more perfect martensitic structure than those that were quenched cold and then drawn. It would be expected that they would be much tougher and have better cutting qualities. It seems reasonable to suppose that a steel cooled slowly through the hardening range would be more completely martensitic whereas the same steel quenched regularly might have in its structure some trapped austenite.

It can be stated further that soft spots in oil hardening steels which harden solid can be detected in the hardening range with absolute certainty by the use of a magnet. The writer has demonstrated this beyond a reasonable doubt. It should be strongly emphasized that a steel taken from the quenching bath in the hardening range should be placed at once in a medium of the proper temperature. Steels withdrawn in the hardening range are very liable to rupture if allowed to cool in the air. The reason is perfectly obvious.

Indeed, it seems almost a miracle that all quenched steels do not fly to pieces and it can only be explained, at least to the writer's mind, by the fact that the Great Creator Himself gave the hardening power of steel for the use of mankind.

The author desires to give acknowledgment and thanks to W. L. Appel, assistant director of testing department, for his able and enthusiastic cooperation in the preparation of this paper.

Directional Properties in Brass Strip

By Maurice Cook (Discussion by J. D. Jevons)

Abstracted from Journal, *Institute of Metals, Vol. 60, 1937*

Several studies of this subject have been published. From them it may be gathered that reductions of at least 50% have to be made prior to an anneal for directional differences to appear in tensile strength; the figure is 35% for an influence on the reduction of area. Final annealings should be as low as possible consistent with the necessity of delivering soft metal, and the intermediate annealings should be at 1300° F. or more.

Dr. Cook's studies were made on 70:30 brass strip, 0.037 in. thick. This is thick enough to develop ears when drawn into ½x0.42-in. cups. All of it was from the same ingot. Penultimate annealing was 1 hr. at either 1025 or 1475° F.; last reductions were various, and final annealing was at 1000, 1150 or 1350° F. for 30 min.

Whenever directional properties were exhibited, the tensile test is least and the ductility is greatest at 45° to the direction of rolling, which agrees with the observation that the ears on the cups invariably occur in this position. With regard to the intensity of the earing effect, or the height of the ears, the values indicate that with a given penultimate annealing temperature the height of the ears increases with the temperature of the final anneal. In other words, in order to avoid undue development of directional properties, the final annealing should not be carried out at high temperatures.

The only exception to the generalization that the height of the ears increases with the temperature of the final annealing is in the group subjected to a penultimate anneal at 1475° F. and finally rolled 10%. This reduction does not break up the large structure sufficiently for normal recrystallization and grain growth to occur in the final annealing. (In well-recrystallized material, the height of the ears produced on cups is not related to the grain size.) The effect of increasing the penultimate annealing temperature from 750 to 1475° F. is, generally, to decrease the height of the ears. According to these experiments, strip yielding cups with the least amount of waviness at the mouth is obtained with a final rolling reduction of 50% in thickness and a low final annealing temperature, i.e. 1000° F.

With this combination the effect of the temperature of the penultimate anneal on the waviness is apparently insignificant, but immediately either of these conditions is departed from, and either the magnitude of the final rolling or the temperature of the final annealing is increased, then the effect of increasing the penultimate annealing temperature in reducing the extent of waviness, becomes increasingly apparent.

A visual examination of the microstructure of annealed brass does not suggest the existence of any directional features or preferred orientation. If, however, the angle which each system of twin bands makes with the direction of rolling is measured to the nearest 5°, and the frequency of each direction plotted radially from a given point, some more precise information becomes available. If no directionality exists, the plotted radii will be more or less equal in length, while any directionality would be revealed by a lengthening of the lines in preferred directions. In specimens which yield flat-topped cups, the orientation turns out to be random. On the other hand, the plot which was obtained on a sample yielding cups with pronounced waves shows much more evidence of preferred orientation, the twinning planes occurring with greatest frequency at right angles to the direction of rolling and with least frequency at 45° to the direction of rolling.

Practical Aspects of the Matter

Discussing the subject from the viewpoint of the user, J. D. Jevons said that directionality manifests itself in three principal ways: *(a)* Thinning of walls (leading in extreme instances to rupture along certain planes in the original sheet); *(b)* uneven flow in the tools (leading to local thinning or *(Continued on page 676)*

Notes on metals used in the Detroit Edison plants in steam generators, piping and turbines operating at elevated steam temperatures. Experimental installations with long service records furnished data for design of most recent equipment

Pipe, Valves and Turbines for High Temperature Steam

THE DEMAND for more power generating capacity during the past year has tended to focus the attention of central-station men on the question of suitable metals that can be used for high temperature equipment, to take advantage of economies from the use of steam up to 925° F. Until about six years ago, 750° F. was the accepted limit for the commercial materials then available. Later development of low alloys with good high temperature properties has made it possible to raise this limit up to 925° F. with resultant gains in over-all efficiency as high as 18% when comparing 400-lb. 700° F. and 800-lb. 900° F. regenerative plant cycles. Part of this gain is due to the higher pressure possible with higher temperature.

The Detroit Edison Co., since 1927, has been interested in these possibilities; in a desire to learn more about the behavior of metals above 750° F., two experimental installations were made. The first, placed in service in the Trenton Channel plant in 1929, consisted of a small oil-fired superheater and piping system designed to handle steam at 1100° F. in order that troubles from creep or plastic flow, should they occur, would be accelerated. Its purpose was to furnish information for the design of the second experiment. It has now been in service over 37,000 hr.

By R. M. Van Duzer, Jr.
Engineer, Production Dept.
Detroit Edison Co.

The second experimental installation was in Delray Power House No. 3, and consisted of a 10,000-kw. turbine and its auxiliaries, high temperature steam piping, and oil-fired superheater. It was first operated with 1000° F. steam the latter part of 1931, and was in service over 26,000 hr. up to February 1937.

Experience gained in its operation of this unit and the necessity for additional, modern equipment in the Conners Creek Plant led to a rebuilding program utilizing equipment designed for higher temperatures. Since 1934, three 30,000 and two 60,000-kw. turbines together with seven new boilers have been placed in service operating with steam at 600 psi. and 825° F. Recently, one 75,000-kw. turbine and three boilers to operate with 815 psi., 910° F. steam were ordered for the Delray plant.

Considerable has been written concerning the properties of steels for service at 800 to 1100° F. and continual development of cheaper and better alloys is taking place. Valuable experience and data have been gained by their use, particularly in oil refineries where temperatures as high as 1100° are not uncommon. Some are reported to be in service at 1400° F.

Much of the information has been collected over a short time when compared with a 15 to 20-year period required for the economic life of a steam plant. Not knowing what may transpire, central-station design must be conservative

so as to insure against major operating troubles.

The high temperature requirements for dependable steam service may be briefly summarized as follows: First, the alloy should undergo no structural changes, seriously lowering the physical properties. Second, the material should have sufficient resistance to creep to permit its use in parts where the total extension must be limited else the equipment will cease to function. Third, it must resist corrosion, either excessive thinning of the wall or intergranular corrosion. Fourth, suitable welding characteristics must permit fabrication in the field where complete heat treatment is not feasible. This last property is not always essential.

These requirements are of varying importance in the component parts of a plant designed for, say, 925° F. Different operating conditions are encountered in the superheater, in the main steam piping system, and in the turbine. The superheater tubes, for instance, must operate 150 to 200° hotter than the piping and turbine because of the temperature gradient through the gas and steam films and the tube wall itself. The resistance to sulphur bearing flue gas on the outside and dissociated steam on the inside is of importance, whereas in the piping or turbine, where temperatures are lower, corrosion is practically absent.

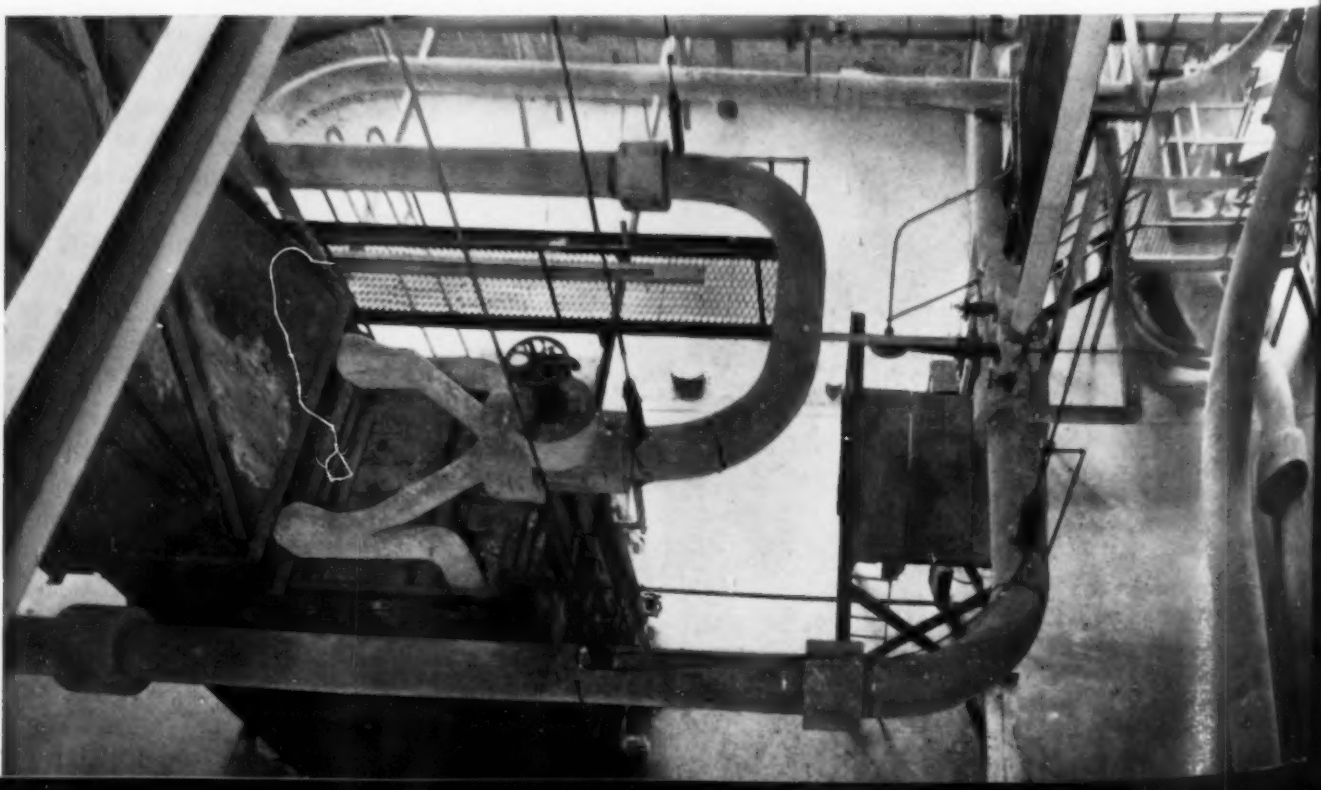
The rapid advance of pipe welding, and its acceptance by code authorities and insurance companies when suitable tests are made, have eliminated all bolted pipe joints from recent designs except at valve bonnets. Valve body and piping must therefore be welded without marked air hardening. Valve body castings should be made from such a weldable material and so designed that growth due to creep does not exceed an arbitrary rate of 1% in 100,000 hr. With such a low rate of extension, it is thought that valves will remain tight over a 15 to 20-year operating period. Tubing, on the other hand, can tolerate a higher rate of extension — ten times that selected for valve design.

The close clearances necessary in the modern turbine make it necessary to limit growth of parts to as small an amount as possible. A recent comprehensive article by E. L. Robinson in the September 1936 Metal Progress discusses this subject in detail. Fortunately, the high temperature is confined to the head end and first few stages of the turbine, since heat energy is rapidly converted into mechanical energy.

Consideration given these problems over a period of ten years is outlined in the following description of Detroit Edison installations, with which the writer is familiar.

The small superheater and piping system at the Trenton Channel Plant designed to handle steam at 1100° F. was built in 1928, when 18% chromium, 8% nickel austenitic steel was being proposed for all high temperature uses. It was selected for all parts of the apparatus because of its outstanding properties, notwithstanding the cost. Two-inch tubing with 0.250-in. wall was used inside the superheater where steam temperature was over 800° F. Other tubing, 5½x⅜ in., with 600-lb. A.S.A. Van Stone joints, was used between the outlet and a de-superheater where the temperature was lowered to 700° F. A 5-in. valve with nitralloy trim was placed at the outlet.

Looking Down at the First Experimental Unit, Superheating Steam to 1100° F. A 65-ft. loop of 5-in. pipe encircles the unit. Trenton Channel plant, 1929



Tubing was specified to have a maximum carbon content of 0.16%, chromium 17 to 20%, and nickel 8 to 10%. Subsequent analyses have shown a carbon range from 0.05 to 0.09%. The valve, flanges and de-superheater were made from "Resistal 2-C," an 18-8 alloy with a maximum of 0.25% carbon and silicon under 2%. All bolts were made from a chromium-tungsten chisel steel. Numerous bolting materials and five other alloys in the so-called low-alloy group were later installed on trial in this pipe.

The materials used in the second experimental unit, installed in Delray Power House, were similar. Superheater tubing for steam temperatures above 800° F. was 18-8 with 0.16% carbon max. and 2.5% silicon max. The silicon was added to combat sulphur corrosion possible with the oil used for firing. Headers and outlet fittings were either cast or forged 18-8 (0.16% carbon max.). In both superheaters the 2-in. tubes comprising the walls of the combustion chamber were protected against direct radiation by a refractory facing.

Low carbon 18-8 tubing (8½ in. x ½ in.) was used between the superheater and turbine. Welded joints and flanged ones were much heavier than those used in the 1100° line. A safety valve at the superheater outlet and a cast fitting were made from 4 to 6% chromium steel containing tungsten; another fitting was made from a straight 0.50% molybdenum composition. Loose flanges were forged from S.A.E. 3240.

Castings used for the high temperature parts of the turbine were made from a Ni-Cr-Mo alloy steel, and the turbine rotor and wheels were machined from a forging of the same. First stage buckets were made of "Midvaloy ATV-1" (36% nickel, 12% chromium, 0.25% carbon), while all nozzles and other buckets were made from 12 to 14% chromium stainless steel. Shaft packing in contact with high temperature steam also was made from this material. The turbine has been described in *Power*, Oct. 27, 1931. The design was such that the high temperature was confined to the front end of the high pressure cylinder, where steam was admitted at 365 psi., 1000° F., and loses 120° in expanding through the first stage.

Information regarding the strength of materials at the time these two installations were designed was mainly that available from a few laboratories. Had there been more service data at hand, the conservative stresses chosen perhaps would have been increased, in order that appreciable creep would have occurred in a few years. All calculations were made on the assumption that the materials behaved elastically at 1000 to 1100° F. This did not give the correct working stress, as the alloys approach the plastic state at the operating temperatures. It did give an indication (on the safe side).

The stress in the superheater tubes at Trenton Channel was 1600 psi. and approximately 3200 psi. in the piping. Joint stresses, however, were enough higher to cause immediate trouble from creep in the bolts. The stresses in the Delray design were stepped up to a maximum of 7400 psi. in the superheater and 6200 psi. in the piping. At points where measurements have been made, no appreciable changes have been found, except in the case of bolted pipe joints. The turbine was designed with stresses under 5000 psi. Stresses as high as 15,000 psi. in straight pipe and plain bends were used in the third or Conners Creek design, and 10,000 psi. at welded joints and in pipe adjacent to creased or corrugated pipe.

Troubles encountered with bolted joints even when the stresses were low emphasized the need for adequate pipe welding technique. The creep of bolts, joint faces and flanges, and the large expansion stresses — the result of the temperature gradient from the inside to the outside of the joint assembly — make the design of a trouble-free, bolted joint rather difficult.

Welding was therefore a major consideration in the selection of materials for the Conners Creek piping. Choice was based on investigations supervised by Prof. A. E. White at the University of Michigan to determine the creep resistance of pipe and valve-body materials. (See *Journal* of American Welding Society for September 1934.)

Metallurgical Information

The pipe was made from a silicon-killed carbon steel according to A.S.T.M. Specification A106-34T, and valve bodies were cast from a 0.28% carbon steel containing 1.05% nickel, 0.70% chromium and 0.40% molybdenum. The tubes in the outlet section of the first two superheaters were fabricated from S.A.E. 6120 and, in later boilers, a 1.25% chromium steel with 0.50% molybdenum was used for tubing. (The latter was described by R. L. Wilson in METAL PROGRESS, September 1935.) A manganese-molybdenum composition was used for turbine castings, turbine wheels were made from Ni-Cr-Mo forgings, and 13% Cr iron was used for buckets and nozzles.

Considerable information has been col-

lected from examination of various materials that have been removed from the Trenton Channel apparatus. No samples have been removed, as yet, from the Delray installation. The most complete data are available concerning the 18-8, four samples of which have been removed:

Change in 18-8 After Service at 1100° F.

	Hours in Service				
	0	6,408	15,535	21,496	35,655
Tensile strength, psi.	91,600	95,100	91,600	113,000	115,000
Elongation, %	53	35	37	38.5	37
Brinell hardness	143	148	152	202	183
Loss in Izod impact					
At 70° F., %	0	5	17.5	68	57
At 1000° F., %	0	19	11	12	..
Carbon content, %	0.05	0.06	0.09	0.05	0.07

The change in hardness and impact strength would indicate a gradual embrittlement; however, the physical properties are still excellent. No evidence of intercrystalline corrosion was found — long exposure to temperature has caused the material to become "re-stabilized." This is proven by determinations of the electrical resistance — a method used by E. C. Bain and his associates in many studies of conditions at the grain boundaries in 18-8. After boiling samples in copper sulphate solution, the third specimen showed a 22-fold increase in resistance, thus indicating unstable conditions at the grain boundaries, while the fourth and fifth specimens showed practically no change, indicating that the chromium removed from the grain boundaries and slip planes by carbide formation had been replenished by migration of chromium from the crystal interior.

Shortly after the 4 to 6% chromium steel with tungsten became available, a valve and a 5½-in. pipe bend of this alloy were installed in the line. Both have since been removed and examined, the valve body after 10,818 hr. of 1100° service and the pipe after 18,150 hr. Physical properties of the cast material before and after service could not be directly compared because of unsound specimens. The samples from the tubing in the "as received" condition and after service were both taken from the same length and the test gives a true indication that no marked changes are caused by service.

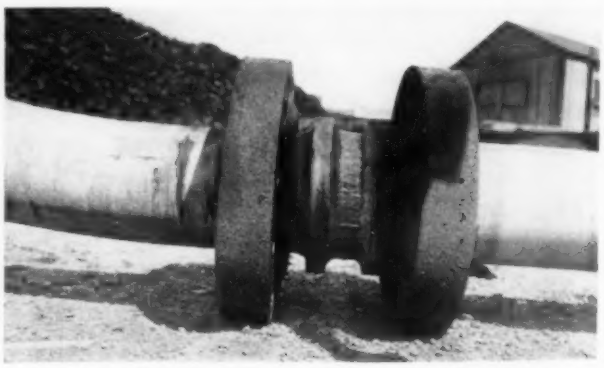
Tubing After 18,150 Hr. at 1100° F.

Chemical Analysis, C 0.11%, Cr 5.6%, W 0.96%

Property	Before Service	After Service
Tensile strength, psi.	77,800	74,900
Yield point, psi.	42,800	41,000
Elongation in 1 in., %	34	34
Reduction of area, %	71	71
Izod impact, ft-lb.	39	34
Hardness, Rockwell B	80	77½

A valve, flange, and de-superheater casting, made from "Resistal 2-C," were examined after cracks occurred in the last mentioned. This alloy, an 18-8 composition with 0.25% C and 2% Si, was in such a poor condition, the result of inclusions and voids, that no conclusions regarding its suitability for high temperature use could be drawn from the service test. The suitability of lower alloy castings has indicated that additional investigation of cast 18-8, now produced in sound form, was unwarranted.

Experience with low and medium carbon



Welded Joint for 8-In. Delray Line (1000°F.), Showing Mechanical Reinforcement Prior to Bolting, 1931

steels, whose surface was protected with aluminum, shows that the surface is protected from corrosion, provided the growth or creep does not spall off the coating. Advances in the method of applying the aluminum have resulted in a more ductile layer; this product, however, has not been tried by the Detroit Edison Co.

Experiences with ten different bolting materials indicate that a material with high creep resistance and high tensile strength will give the longest service without trouble. The temperature differential between inside and outside of a bolted joint sets up large stresses during the warming-up process and subsequent operation. These stresses were so great in some of the original joints that 18-8 bolts, while possessing

excellent high temperature properties, would stretch enough during the start-up period to cause leakage. The alloy giving the best service was a chisel steel (0.50% C, 1.25% Cr, 2.0% W), even though it is expensive, difficult to thread after being heat treated to 400 Brinell, and not entirely stable (structurally) at temperature. The decrease in maintenance more than offset the high initial cost. Its changes in properties after service are shown in the table below.

Some of the bolts in the second group have been annealed and re-heat treated to restore the original physical properties.

The question of suitable materials for valve seating use has been investigated both from the standpoint of corrosion and wear resistance. Nitralloy, first adopted for valve trim, possesses excellent wearing qualities at 1000° F. but loses hardness and corrodes after prolonged exposure. All of the stainless steel combinations tested, while not suffering from corrosion, had a tendency to score when the valve was opened against 400-lb. pressure. Stellite, because of its high red hardness and stainless features, has given good service and appears to be the best material at present available.

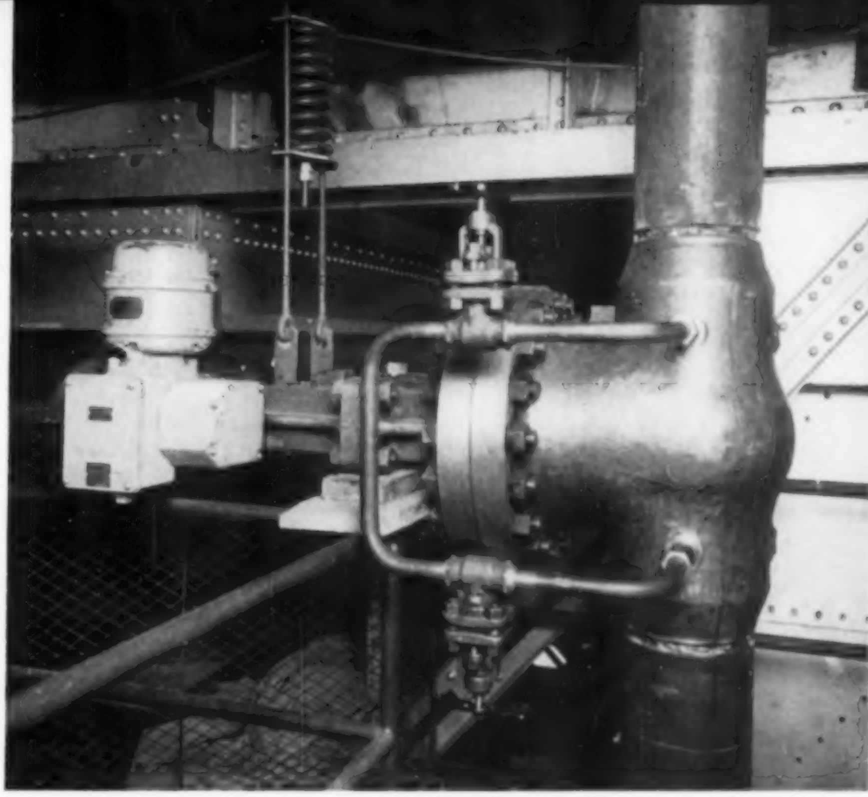
Examination of material from the Delray installation has been confined to an investigation of the supposed embrittling tendency of the steel used in the turbine. This has 0.30% C, 0.35% Cr, 3.10% Ni and 0.34% Mo. Results published in England on similar wrought material tested at 842° F. and stressed as high as 20,000 psi., showed susceptibility to embrittlement, but similar tests conducted on the cast turbine material at 1000° F. failed to indicate any.

Cr-W Bolts After Service at 1025° F.

Chemical Analysis, C 0.45 to 0.50%, Cr 1.25%, W 2.0%

	Group in Service 6408 Hr.		Group in Service 10,575 Hr.	
	Before	After	Before	After
Tensile strength, psi.	214,000	213,000	225,000	163,000
Yield point, psi.	204,000	202,000	210,000	....
Elongation in 2 in., %	11	12	11	14.4
Reduction of area, %	36	37.5	33	42.5
Brinell hardness	457	400	462	338
Izod impact, ft-lb.	...	...	12.5	8.5

A piece of 5-in. tubing made of 1.25% Cr, 0.50% Mo steel was recently installed in the 1100° steam main to determine the extent of creep, steam attack, and change in microstructure. This contained two accurately machined cross-sections of different thicknesses to which stainless steel measuring points were attached. The test has not progressed far enough (1800 hr.) for any definite conclusions to be drawn other than to say that the creep rate compares closely with laboratory results.



Motor Operated Valve in 10-In. Line Positioned Ready for Welding. Operates at 600 lb., 825° F. Conners Creek, 1934

No troubles have developed from corrosion by steam, mainly because of the extensive use made of 18-8 and the heavy sections used in the low alloy castings. This subject, however, is one of increasing interest in view of the extensive use now being made of low alloy superheater tubes in new and proposed power plants.

Examination of S.A.E. 6120 tubes removed from the Conners Creek superheater, supplying steam at 840° F., indicates the formation of black magnetic iron oxide equivalent to about 0.05 lb. of iron per sq.ft. of surface during an operating period of 9000 hr. This is equivalent to a loss in original tube wall of 0.09% in 1000 hr. While not serious in this case, where maximum *tube* temperatures are approximately 950° F., it becomes of importance when *steam* temperatures of 900 to 925° F. are contemplated, and necessitates the adoption of better constructional materials.

This subject is now under study at Purdue University. A series of samples has been installed in the 1100° F. steam main at Trenton Channel to determine the rate of steam attack. This group includes nine steels ranging from

Assembling the Special Design of High Pressure Casing and Rotor Which Eliminates a Split Joint in the Outer Casing. Rotor and inner split casing retaining the diaphragms are being lowered into the outer solid casing. Delray plant, 1930

low carbon up to and including 18-8 steel.

Perhaps the main result obtained from the experimental installations, aside from satisfactory behavior of the metals selected, was the impetus given to the development of pipe welding. The troubles met with flanged pipe joints and later, to a lesser degree, with heavier designs, showed that a welded joint eliminated troubles caused by high thermal stresses and creep of bolts, flanges, and joint faces — all inherent in a bolted assembly.

Extensive use was made of welding in the construction of the Delray equipment, but in all except one case where full-strength flash welds were used the design relied mainly on mechanical reinforcement, the weld being merely a sealing medium. At the time work was started on the 825° F. units in Conners Creek, welds were being made under field conditions that were considered satisfactory for the temperature and pressure. The proper education of welders, the development of a heating device for stress relief, and the use of the arcronograph all had a part in the sound pipe welds that were obtained. Interested readers are referred to an article, "Modernizing The Conners Creek Power Plant" in *Combustion* for March 1936.

As additional equipment was installed more extensive use has been made of welding. The only bolted joints to be found in the last addition of equipment, placed in service in April of this year, are those at the valve bonnet joints in the high temperature piping and at the turbine inlet. Bolted joints have been eliminated at the boiler and at the turbine stop valve, and in smaller miscellaneous piping. Those at the turbine inlet were retained to facilitate turbine maintenance.

In over two years of operation, the only troubles due to leakage have been at two valve bonnet joints. Aside from trouble-free operation, considerable piping cost has been saved, and all cast fittings other than valve bodies have been eliminated.

Turbine and boiler equipment that will go in service during the middle of 1938 at Delray Power House No. 3 will operate with steam at 815 psi. and 900° F. The superheater will be composed of low carbon, carbon-molybdenum steel and 5% Cr-Mo tubing arranged in the order of increasing steam temperature. The main steam piping probably will be made from carbon-molybdenum steel. A low alloy similar to that in service at Conners Creek will be selected for the valve body castings; it contains 0.28% C, 1.0% Ni, 0.70% Cr and 0.40% Mo, and while slightly air hardening can be welded readily. The turbine steels probably will be similar to those already described; experience with the Delray turbine using low alloy steels at 1000° F. would indicate that these materials will be satisfactory for service at 900° F.

In closing, it may be said that although operation of the 1000° F. turbine has demonstrated the practicability of design for this temperature, equipment for temperatures much above 925° F. is not now being built. As temperatures are increased, it is necessary that the savings more than offset the increased fixed charges resulting from higher capital expenditures. With lowering of manufacturing costs through availability of high temperature materials, with increase in fuel costs, or a change in other factors magnifying savings, apparatus will be built for higher temperatures.

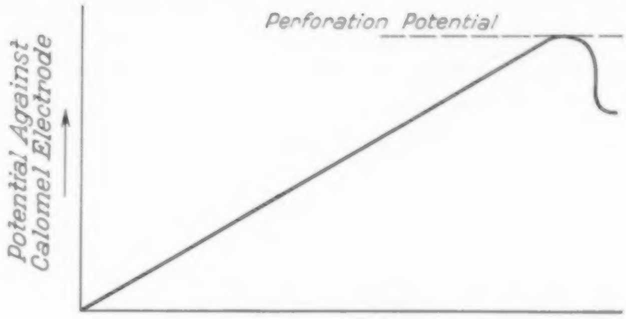
Local Corrodibility of Stainless

Special letter to METAL PROGRESS by SVEN BRENNERT

Technical Director, DeLaval Separator Co. of Sweden

STOCKHOLM, *Sweden* — In the manufacture of creamery and other food handling equipment the use of stainless steel is widespread, but troubles with the pitting type of corrosion have been experienced where sea water is used for a cooling medium. This matter has been under investigation in our research laboratory for some time, and some of our studies may be of interest to Americans who have been concerned with this same problem.

It is known that the resistance of metals to corrosion is reduced in places where they are in contact with the same or another material, and in surfaces which have been severely injured by cold work — for instance, by cutting or shearing. When placing a cut plate of stainless steel in a sodium chloride solution, it is attacked (if at all) at the cut edges. If the edges are covered by an insulating medium like vaseline, the first attack then frequently takes place along boundary lines between the insulation and the steel. If the specimen is lying against the bottom of the vessel, and if the cut edges have been insulated, the first action occurs where the material touches the vessel.



Perforation of Protective Film Occurs at Peak of Voltage-Time (Voltage-Amperage) Curve

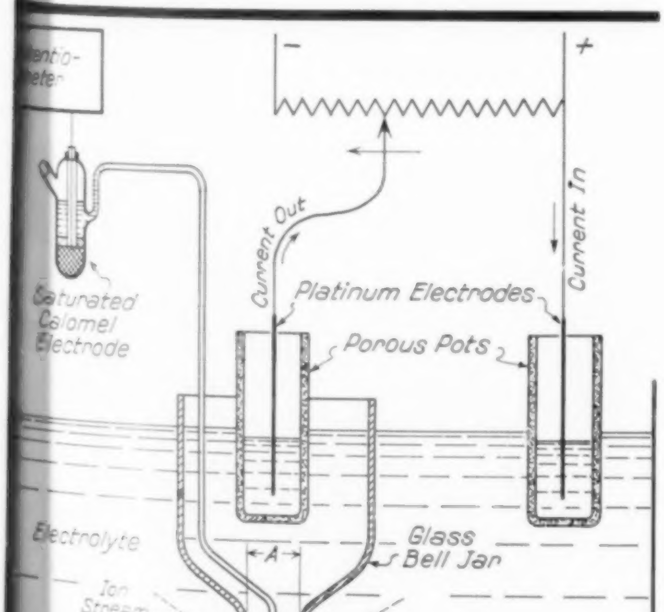


Diagram of Apparatus for Determining Relative Corrodibility of Stainless Steel in Neutral Solutions

Various hypotheses about the reason for this localized corrosion have been advanced. Evidently the passivating film is weaker at these points. One view is that oxygen can diffuse less readily to these partly covered places and the self-healing effect wherein the damaged oxide coat is rebuilt is more difficult. Others think that the passive or oxide film is weakened by certain capillary forces in the covered parts. Severe cold work introduces internal stresses in the steel and this is thought to have some effect on the tightness of the passivating film.

The present writer published a means whereby such variations in corrosion resistance could be measured (Jernkontorets *Annaler*, 1935, page 281). The principle of this method is that the surface to be examined is exposed to an increasing anodic polarization in relation to the solution; it is then determined how far the polarization can be raised without inducing localized attack.

The test is made by means of an apparatus which is schematically shown in the figure. If a current is led through the solution as indicated, the surface *A* below the neck in the glass

bell jar is anodically polarized because of the fall of potential in the narrow ring of liquid between bell jar and specimen. Anodic polarization only occurs within this circle marked as *A*; since there are no cut edges, contact surfaces or the like in this region of first quality plate, the test is made on a homogeneous surface without its being influenced by other disturbing factors.

This induced potential is measured in relation to a saturated calomel electrode. As the current put through the electrolyte is gradually increased, the potential of the surface in relation to the calomel electrode is continuously raised until the passive surface is perforated. The potential then quickly falls, for the underlying, less noble material is uncovered, which causes the potential of the test surface *A* to be changed in a negative (less noble) direction. This maximum potential is called the "perforation potential" and is regarded as a measure of the resistance of the given material to corrosion by the electrolyte in the experiment.

The normal surface of various high chromium alloys has been studied in this way. The perforation potential in 0.1N sodium chloride solution at 25° C. is as follows: 18-8, 0.45 to 0.55 volt; 18-8 with 1.5% Mo, 0.55 to 0.65 volt; 12% Cr, 0.0 to 0.1 volt; 20% Cr, 0.3 to 0.4 volt.

In the above the plates were annealed at 2000° F., ground on a band with "Durexite No. 120," pickled in $HCl+FeCl_3$, and then dipped 30 sec. in nitric acid. With unsuitable steel making or treating practice, or with unsuitable treatment of the surface, these values may be considerably lower.

The edge effect was studied by clamping together a nest of annealed sheets and placing the pile, edges up, in the same relative position as shown in the sketch, other conditions remaining constant. Perforation potentials in four tests were as follows: 0.44, 0.42, 0.41 and 0.43, an average of 0.43 volt.

Next, a fresh sheet of annealed 18-8 had a round spot of vaseline, slightly smaller than *A* in diameter, centered accurately under the bell jar. Five such tests gave perforation potentials varying from 0.45 to 0.53, an average of 0.48 volt. This may be compared with an average of 0.50 volt for the clean 18-8 surface. This reduction is insignificant with that obtained on a surface contacting a rubber washer bolted to the surface; four tests gave perforation potentials of 0.34 to 0.38 volt, an average of 0.36 volt. This verifies practical experience, where it has been found that very few, if any, substances can reduce the corrosion resistance to so great an extent. This seems to be due to the material adhering to the metal without really covering it; there is always a certain small play.

It is often said that a moderate cold working, as cold rolling, enhances the pitting of stainless steels. We believe, however, that this effect is rather insignificant. For instance, a lot of 18-8 annealed and cold rolled to Rockwell B-108 had a perforation potential of 0.39 volt (average), whereas the same materials after re-annealing and softening to B-82 had a perforation potential of 0.40 volt. It is only in cases where the surface is injured, as, for instance, by cutting and turning, that a very distinct fall in the corrosion resistance is noted.

Some other interesting results are being reported to the current meeting in London of the International Association for Testing Materials. Studying the relation of temperature of the 0.1N salt solution to the perforation potential of 18-8, we find that this value is about 0.80 volt at 55° F., 0.50 volt at 75° F., 0.20 volt at 110° F., and approaches zero at 160° F. and above. This fact is well known from practice as well as from laboratory tests, though earlier laboratory tests did not give a quantitative, but only a qualitative expression of these variations in resistance to corrosion. Thus, it is well known that hot water containers should not be made of 18-8 stainless steel, because they are easily destroyed by the formation of pits. On the other hand, cold water containers are preferably made of this material.

SVEN BRENNERT

Der Sultan von Messing

WATERBURY, *Conn.* — Knowing that METAL PROGRESS is always on the lookout for the unusual in photography, I enclose the unusual in micrographs. You will note that this piece of brass exhibited the perfect head of an oriental, turban and all.

WM. B. PRICE

Crystallography of the Chemical Elements

As Tabulated by William Hume-Rothery
in "The Structure of Metals and Alloys" Monograph No 1, British Institute of Metals

Element Atomic No.	Electron Arrangement in Free Atoms	Crystal Structure (note a)	Axial Ratio $c \div a$	Coordination No.	Lattice Constant a	Lattice Constant c	Interatomic Distance d_1	Interatomic Distance d_2	Atomic Diameter (Coordination No. 12)
Group IA in Periodic Sequence									
3 Lithium	(2)1	⊞	—	8	3.51±0.04	—	3.04	—	3.13
11 Sodium	(2)(8)1	⊞	—	8	4.30±0.04	—	3.72	—	3.83
19 Potassium	(2)(8)(8)1	⊞	—	8	5.333_5	—	4.618	—	4.76
37 Rubidium	(2)(8)(18)(8)1	⊞	—	8	5.62±0.03 at -173°C.	—	4.87 at -173°C.	—	5.02
55 Cesium	(2)(8)(18)(18)(8)1	⊞	—	8	6.05±0.03 at -173°C.	—	5.24 at -173°C.	—	5.40
87 Virginium	(2)(8)(18)(32)(18)(8)1	—	—	—	—	—	—	—	
Group IB									
29 Copper	(2)(8)(18)1	⊡	—	12	3.607_8	—	2.551_1	—	2.551
47 Silver	(2)(8)(18)(18)1	⊡	—	12	4.077_8	—	2.883_5	—	2.883
79 Gold	(2)(8)(18)(32)(18)1	⊡	—	12	4.069_9	—	2.877_8	—	2.877
Group IIA in Periodic Sequence									
4 Beryllium	(2)2	⬡	1.584_8	6,6	2.267_9	3.594_2	2.223_5	2.267_9	2.25
12 Magnesium	(2)(8)2	⬡	1.6236	6,6	3.202_2	5.199_1	3.190_0	3.202_2	3.20
20 Calcium	(2)(8)(8)2	α=⊡	—	12	5.56	—	3.93	—	3.93
(data for 450°C.) →		β=⬡	1.640	6,6	3.94	6.46	3.94	3.955	3.98
38 Strontium	(2)(8)(18)(8)2	⊡	—	12	6.07_5	—	4.29_6	—	4.29_6
56 Barium	(2)(8)(18)(18)(8)2	⊞	—	8	5.015	—	4.34_3	—	4.48
88 Radium	(2)(8)(18)(32)(18)(8)2		—	—	—	—	—	—	—
Group IIB									
30 Zinc	(2)(8)(18)2	⬡	1.8560	6,6	2.659_0	4.935_1	2.659_0	2.906_1	2.748
48 Cadmium	(2)(8)(18)(18)2	⬡	1.885_2	6,6	2.973_6	5.606_9	2.973_6	3.287_2	3.042
80 Mercury	(2)(8)(18)(32)(18)2	▱	α=70°31.7′	6	2.999 ←	at -46°C.	2.999	—	3.10
Group IIIA in Periodic Sequence									
5 Boron	(2)3		—	—	—	—	—	—	2.80 to 2.86 (note b)
13 Aluminum	(2)(8)3	⊡	—	12	4.041_4	—	2.856_8	←	
21 Scandium	(2)(8)(9)2		—	—	—	—	—	—	
39 Yttrium	(2)(8)(18)(9)2	⬡	1.588	6,6	3.66_3	5.81_4	3.59_5	3.66_3	3.62_9
57 Lanthanum	(2)(8)(18)(18)(9)2	α=⬡	1.613	6,6	3.75_4	6.06_3	3.72_7	3.75_4	3.741
		β=⊡		12	5.29_6		3.754		3.745
89 Actinium	(2)(8)(18)(32)(18)(9)2		—	—	—	—	—	—	—
Group IIIB									
31 Gallium	(2)(8)(18)3	▯	—	—	4.5167	7.6448	(note c)	—	—
		a÷b÷c=1:0.99868:1.69257			b=4.5107				
49 Indium	(2)(8)(18)(18)3	◬	1.077	4,8	4.58_3	4.93_6	4 at 3.24_1	8 at 3.36_8	3.138
81 Thallium	(2)(8)(18)(32)(18)3	α=⬡	1.60_0	6,6	3.45_0	5.52_0	3.40_4	3.45_0	3.427
		β=⊡	—	12	4.84_1	—	3.42_3	—	3.42_3

Notes: (a) ⊞ is body-centered cubic; ⊡ is face-centered cubic; ⬡ is close packed hexagonal; ▱ is simple rhombohedral; ▯ is orthorhombic; ◬ is face-centered tetragonal

(b) Appears to be smaller in some alloys

(c) 8 atoms to unit cell; each atom has 1 neighbor at 2.43_7, 2 at 2.70_6, 2 at 2.73_6 and 2 at 2.79_5

Reviews of Recent Books

Architecture of the Metallic State

The Structure of Metals and Alloys, by WILLIAM HUME-ROTHERY. 120 pages, $5\frac{1}{2}$x$8\frac{1}{2}$ in., 61 illustrations. Bound in limp cloth. Institute of Metals, 36 Victoria St., London, S.W.1, England. Price 3s. 6d.

Reviewed by KENT R. VAN HORN
Aluminum Co. of America

The Institute of Metals (London) recently has added another series of excellent publications to the valuable contributions which are regularly issued. The plan is to present a series of reports and monographs summarizing in a convenient form the recent work, during the past ten active years, in different fields related to metallurgy. Although the British Chemical Society and Physical Society initiated a somewhat similar practice previously, it is quite apparent that the Institute of Metals has proposed to undertake an even better, if not more difficult, program. This first monograph on the Structure of Metals and Alloys is fundamental to physical metallurgy and most fortunately was prepared by that distinguished scientist and recognized authority in the field, William Hume-Rothery.

The author is to be congratulated on the clear, interesting, and condensed account of the present day concepts of the structure of alloys. Many metallurgists will be relieved to learn that he has accomplished this objective without resorting to the dreaded crystallographic notations, the higher realms of mathematics and wave mechanics generally associated with discussions on atomic structure. In fact, even the thermodynamic treatment of constitutional diagrams is judiciously avoided. A knowledge of simple arithmetic and a little trigonometry will suffice. However, the book is *not* light reading throughout, but certainly is as easy reading as the subject permits. So much for the minor virtues of the monograph.

A comprehensive and brief treatise on the structure of metals and alloys is indeed welcome and most timely. More detailed books on X-rays or atomic structure are available but are generally very involved and little space is devoted to the study of intermetallic reactions. Likewise few metallography text books attempt, as yet, to show the principles underlying constitutional diagrams. Dr. Hume-Rothery presents a plan for the relations or combinations of metals, based on the present known data, in the hope that it might eventually lead to the construction of a complete map with all facts clearly revealed. The intermetallic phases are not formed as haphazardly as was previously conceived, but, in many cases, a simple relation seems to exist between the atomic arrangement, the properties of the alloys and the type of constitutional diagram representing the equilibrium relations of the phases. Certain principles governing the coupling of atoms into intermediate phases have been traced, and structural analogies have been shown to exist between different alloy systems.

The contents of the monograph may be briefly indicated at the risk of being reminded that a review should not be a summary of what the book contains. The introductory sections describe the modern concepts of the structure of the atom, molecule, crystal, the crystal structure of the elements and tabular data on the atomic radii of the elements. The major section is devoted to the structure and constitutional relations of solid solutions and intermediate phases.

The monograph will be appreciated by metallurgists and certainly deserves extensive circulation. Also many scientists in the allied fields of chemistry and physics will find the treatment most interesting and valuable. And now, saving a most palatable morsel to the last,

the monograph of 120 pages and 61 illustrations sells for only about 85c at the current rate of exchange! Certainly this is a pleasant surprise to those who are accustomed to dig deep into their pockets to purchase technical books. Both the quality and the cost of the monograph represent another notable achievement of our worthy contemporary society, the British Institute of Metals, of which we, from past experience, would expect no less.

What Is it, and Who Makes it?

Engineering Alloys, by Norman E. Woldman and Albert J. Dornblatt. 622 pages, 6¼x9¼ in. Published by American Society for Metals, Cleveland. Price $10.00.

Reviewed by E. L. Sinclair
Material Engineer, U. S. Navy

In this book the authors have compiled data on over 8200 commercial alloys. The reader can easily obtain the name, composition, properties, uses, and manufacture of practically any commercial proprietary alloy. Knowing either the name, manufacturer, or the use of an alloy, the searcher can easily locate the desired information because of the condensed and efficient manner in which the data are presented.

The book is divided into seven sections. Section I, Alloy Index, is an alphabetical list of the alloys with their assigned serial numbers. The serial number locates the data relative to a given alloy in Section II, entitled Alloy Data. In this section, alloys are listed according to their respective serial numbers. The source from which the data were obtained and the manufacturer of the alloy are designated by key numbers. Section III, Alloy Classification and Uses Index, is the section in which the alloys, represented by their serial numbers, are classified according to special characteristics and typical uses. Section IV, Directory of Manufacturers and Their Alloys, lists the manufacturers and the alloys produced by each, by names and serial numbers. Section V is the Key Index to Manufacturers referred to in Section II. Section VI consists of Bibliography and References. Section VII is a Useful Data Appendix. This last section consists of conversion tables, definitions of terms relating to testing and heat treatment, and a classification of the multitudinous corrosion and heat resisting alloys according to their chemical composition.

Engineering Alloys is therefore not a text book with detailed information on methods of manufacture, production, and treatments of alloys. It is a practical and technical reference book on engineering alloys. The book enables the reader to identify an alloy quickly; if detailed information is desired, the book gives the basis for one to start on its collection, giving the manufacturer, who may be contacted, and a list of references.

The need for this book of such concise presentation, yet containing a large amount of information in its 622 pages, will be recognized by even a rapid survey of its contents.

The commercial alloys are many and their uses numerous and varied. Some alloys are well known, others not so well known. Information is often requested of those in the metallurgical profession about some alloy that may not be so well known or an alloy in a different field from his own specialized line. Trade names only may be mentioned as the specified material for certain parts in assemblies and equipment. In such ways as these and many others the book fills the need for a reference to tell you quickly "what it is."

The value of the book is recognized by the late Prof. William Campbell, to whom the book is dedicated and who wrote the introduction. Instead of looking up abstracts and indexes, to quote Professor Campbell, one need only say, "Look it up in Woldman and Dornblatt's Engineering Alloys."

The authors have indeed done a large volume of painstaking work and rendered a service of high merit.

A Successor to Metcalf's "Steel"

Tool Steel Simplified, by Frank R. Palmer. 316 pages, 6x9 in., 203 illustrations. Published by Carpenter Steel Co., Reading, Pa. Price $1.00 in U.S.A., $3.50 elsewhere.

After 27 years of work with American toolsteels William Metcalf sat down and wrote "Steel, a Manual for Steel Users." That was in 1896, and it became a best seller among technical books. Some of his remarks on alloy steels now sound a little quaint, but that did not limit the usefulness of the old booklet very much, for most of the toolsteel then and for many years thereafter was carbon toolsteel. Metcalf put down a lot of true talk about how to treat good crucible steel and how to avoid mistreating it, and while doing so debunked a lot of phonies

— "quacks and humbugs" he called them in the more decorous Victorian language.

It seems about time another manufacturer did the same thing for the toolsteels of today. The occasion obviously had to wait for a certain conjunction of the planets: A man who knows his stuff, has a salty phraseology, works with a progressive toolsteel organization, and one that is willing to take its customers (in fact, the trade generally) into its confidence.

That propitious time has arrived, for "Tool Steel Simplified — a Handbook of Modern Practice for the Man Who Makes Tools" comes now, a worthy successor to Metcalf's "Steel." Mr. Palmer is so frequent and welcome a speaker at ⊕ chapter meetings that no words are here necessary to describe the way he puts forward new viewpoints. There is nothing mealy-mouthed about it. Now and then it is propaganda for Carpenter Steel Co. but it is boldly propaganda; no one need mistake it. Practically all of it is true talk, and while an industrious critic could find minor flaws here and there, one cannot help but realize that here is a sincere effort to tell tool designers, makers and users the things they ought to know (limited only by what Mr. Palmer really *knows*) about the selection of steel and its correct heat treatment.

As to selection of steel, he emphasizes that water hardening carbon toolsteel is "home, the place where a person stays all the time unless he has a good reason for going somewhere else." Alloys, he believes, are therefore good for four reasons and four only — to get more wear resistance than a well-made and well-treated carbon steel can give, more toughness or strength, more size accuracy and safety, or the property of red hardness. He develops the thesis that all possible permutations and combinations of these may be had with nine types of steel; all others are "prima donnas — she can do *one* thing almost perfectly, but she can't (or won't) darn socks, fry eggs, play tennis or redecorate the livingroom."

In addition to chemical analysis as ordinarily reported, the influence of "timbre" is also adequately discussed, a word early used by Mr. Palmer's associates and B. F. Shepherd of Ingersoll-Rand Co. (past president ⊕) to describe generally the more recently investigated phenomena of inherent grain size, grain growth characteristics and hardening depth.

If anyone thinks these two things above mentioned are easy to explain to a toolmaker, let him try it!

E. E. Thum

Large Tin Cans in Storage

Metal for Food Containers

Tinplate and Tin Can Manufacture in the United States, by Bruce W. Gonser. 144 pages, $8\frac{1}{4}$x$10\frac{1}{2}$ in., 159 illustrations. Paper cover. Published by International Tin Research and Development Council, 149 Broadway, New York, for controlled circulation.

Reviewed by C. C. Willits
Standard Tin Plate Co.

This beautifully printed booklet has been prepared by the Battelle Memorial Institute as Bulletin No. 4 of the International Tin Research and Development Council. It is the first coherent description available in print of the modern manufacturing processes for the production of tinplate and tin cans. Most ably written, supported by excellent photographs that in themselves are pictorial stories, by history, highly informative maps, charts, and tables, there is no cessation of interesting and instructive reading from the time the reader — be he layman or technician — is introduced to the subject until the time he makes his final adieu to the finished can.

Some of the outstanding achievements by the tinplate and tin can industry in the United States featured are recent developments in continuous rolling practice; hot and cold reduced base plate strip; the abolition of the practice of hand tinning of the base plate for that of the mechanically operated tin pot with resultant more uniform tin coatings and better cans at higher speeds of production — for some types 300 to 400 cans per minute; protective sanitary linings for cans; improved decorating methods; high class technical supervision, more rigid

inspection, and higher quality products generally.

It is a long trek from the southeastern corner of Asia, where most of the world's supply of tin ore is obtained, to my lady's kitchen in the United States where many tin cans reach the end of their usefulness. But, step by step, under the guidance of Dr. Gonser and his co-authors of the Battelle Memorial Institute, H. W. Gillett, H. W. Russell, and S. Epstein, one makes the different stages quickly, entertainingly, and comprehensively as has not been possible heretofore.

The authors deserve high commendation for this excellent contribution to a rather barren area in the field of industrial literature. The International Tin Research and Development Council are also to be commended for their foresight in placing this subject before the Battelle Memorial Institute. A copy of this booklet should be on the "must" reading list of every tinplate and tin can manufacturing plant; as well as the packers and their customers.

The Late Henry Le Chatelier

Special Issue of *La Revue de Métallurgie* for January 1937, dedicated to the memory of Henry Le Chatelier. Paper bound, 8½x10½ in., 160 pages. Price 30 francs.

No more fitting honor for its founder and director from 1904 to 1920 could *La Revue de Métallurgie* have devised than this complete and well-arranged biographical appreciation of Henry Le Chatelier, honorary member ⊕, to whom death came last fall at the age of 86.

Although his most important contribution to science was probably his work on pyrometry and high temperature measurement, his field of activity was wide and is described in seven chapters dealing with his life, his work in metallurgy, in the constitution of metallic alloys, chemistry, cement, explosives, and industrial applications of scientific findings. These divisions are written by different authors including such illustrious names as Guillet, Charpy, Portevin and Chevenard.

Following come 25 notes honoring Le Chatelier written by leading scientists in all civilized countries. Finally is a 16-page bibliography of the works of this prolific scientist.

Although this method of presentation is necessarily repetitious and sometimes overwhelming in the lavishness of its laudation, nevertheless it leaves one with a feeling of personal acquaintanceship with a man who was great not only scientifically, but mentally, morally and spiritually as well. M. R. Hyslop

Quality Steels, Made in Germany

Die Edelstähle, by F. Rapatz. Second Edition. 386 pages, 163 illustrations. Published by Julius Springer, Berlin, W9, Germany. Price 22.80 Reichsmarks (subject to discount for foreign sale).

Reviewed by Marcus A. Grossmann
Carnegie-Illinois Steel Corp.

As the author says in the introduction to this second edition, there has been much progress since 1924 (the date of the first) and many new points of view have developed. The present book is therefore largely new.

Its scope is perhaps best described by listing the space devoted to the several items: Theories 62 p., alloy steels 110 p., strength properties 23 p., applications 163 p., inspection, manufacturing and defects 13 p.

It is clear then that the major portion of the book is devoted to a description of the effects of alloys on the properties of steel, and the manner in which these effects are employed in suiting steels to industrial service. Therein lies its value. It provides a ready reference work for those who wish to obtain information quickly on the application of special steels for specific applications. The book is small and indeed not an encyclopedia, but within the limits of its size it furnishes valuable information as well as adequate reference to the work of others. If the references in it include more commonly the work of Europeans, it must be remembered that this is only natural for a European book. Undoubtedly our American books err in a corresponding manner.

It has been pointed out that this is essentially a book for practical reference. The fundamental or theoretical side is therefore handled less completely. Perhaps future editions will contain more of the still more recent conceptions of steel behavior. Thus the section on "hardening sensitivity" could well be expanded to include the now familiar conceptions of grain coarsening and carbide solution with their attendant greater hardenability, and there could to advantage be further discussion of rates of reaction in hardening, although the latter is indeed mentioned briefly.

In the section on alloy steels, the references

(Continued on page 650)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are quite complete and adequate, including some interesting items on the much less common elements. The more common alloying elements, such as manganese, chromium, nickel, tungsten, molybdenum and vanadium, are treated at some length, devoting some six to ten pages to each of these elements. One finds in general that the percentages of alloying elements appearing in the quality steels made in Germany are similar to those used in this country. Indeed, there is frequent reference to American publications. There are brief notes also on such elements as boron, beryllium, arsenic, selenium and the like, and short discussions of the effect of titanium, copper and uranium on steel.

The section on steel applications presents a good picture of the present state of the art in Central Europe, and it is noticeable that the points of view are quite like those obtaining in the United States. As to mechanical properties, there is a small section of tables which supplement the mechanical properties already listed under the several alloying elements. Further fields of application include the magnet steels and the electrical steels including transformer sheets. A considerable section is devoted to the stainless steels and heat resisting steels. A special division discusses high speed steels and this is followed by extensive discussion of the tungsten-carbide type of cutting tools, ending with a discussion of the general problem of machinability.

The book may therefore be recommended to those reading German as a concise treatise on the practical applications of alloy steels.

Malleable Castings

La Malleable, by Maurice Leroyer. 227 pages, 6x10 in., 118 illustrations. Published by Dunod, 92 Rue Bonaparte, Paris, (VI), France.

Reviewed by E. K. Smith
Electro Metallurgical Co.

This rather brief book contains a great amount of up-to-date information on malleable castings of all types. The author is gifted with a concise style and has condensed most of the information on this subject into a very readable and comprehensive treatise. M. Leroyer has a happy faculty of presenting both theory and practice in such a way that one who has read his book from cover to cover will have a complete idea of the way in which malleable castings are made and used throughout the world.

Fortunately, the author is impartial, and there is a refreshing freedom from opinionated talk. In controversial subjects he usually states first the side favored by the majority, then the arguments of the minority, finally giving his own opinion with reasons therefor.

In covering this subject, he has drawn very freely from published work in the United States. He also has cited a good deal from German and Japanese abstracts, and surprisingly little from the British.

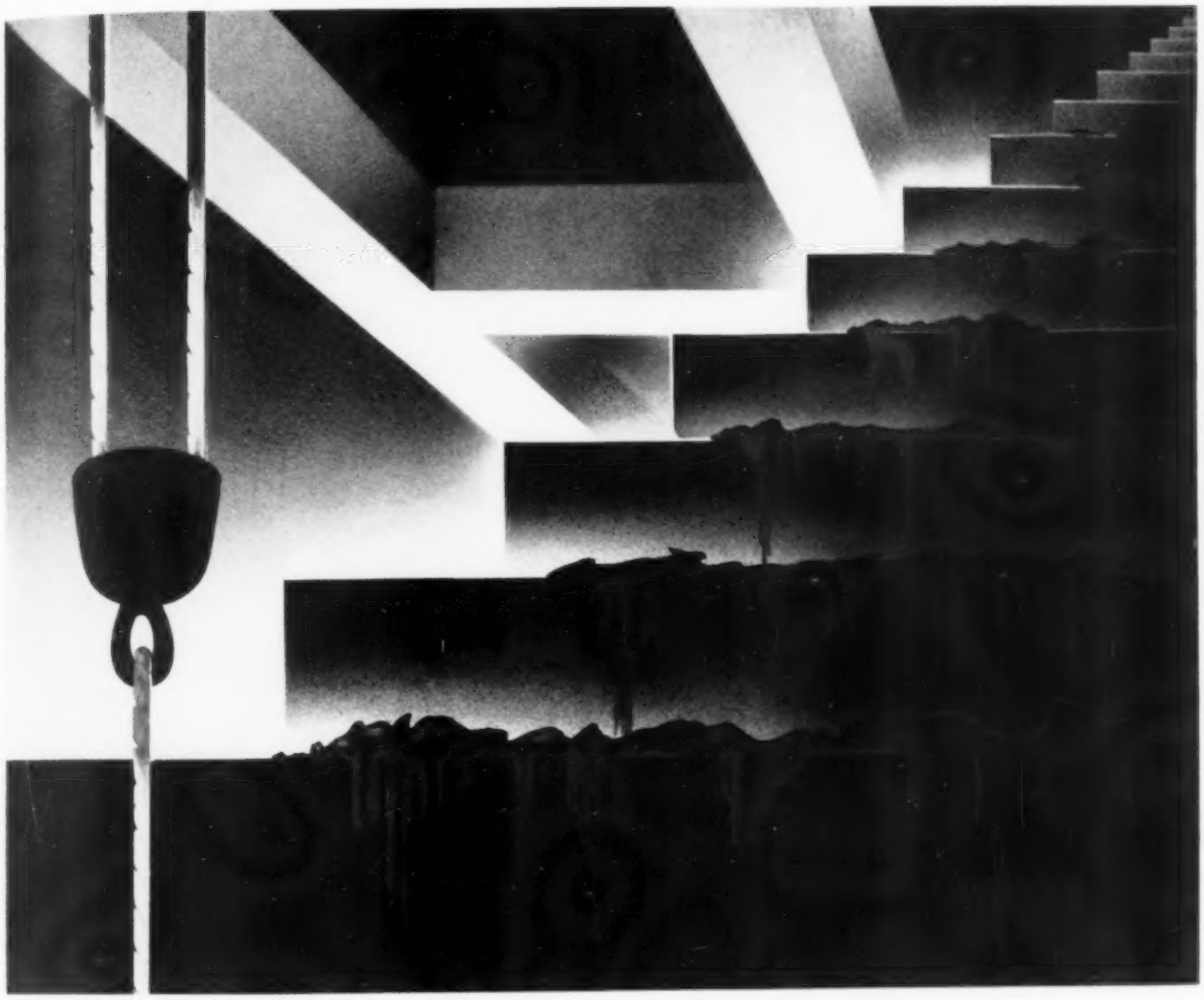
Among the subjects of practical as well as theoretical interest which are thoroughly discussed is the phenomenon of embrittlement of malleable. The author points out the similarity to Krupp Krankheit ("steel sickness"), stating that this phenomenon can generally be attributed to variations in the solubility in alpha iron of various elements or compounds, particularly of nitrogen, oxygen, and phosphorus.

Theories of decarbonization and anneal are discussed thoroughly, with special reference to the work of Matsubara, Schenck, Schwartz, Wust, Honda, Murakami, White, Lederbur, and others. In this connection the author shows his very practical knowledge of the subject by going into the effect of decarbonized rims on turning and tapping, which is of great interest to machine shops dealing with malleable castings.

The author's discussion of all types of melting and annealing is excellent. He, of course, covers standard processes and also brings in a large amount of practical information — for instance, the effect of cooling on physical properties, the influence of gas and packing, the

(Continued on page 652)

Courtesy Cincinnati Milling Machine and Cincinnati



results obtainable by various quick anneals, and the effect of high carbon with rapid cooling. The author shows excellent examples of unusual malleables. In particular, the micrographs showing cementite network in a malleable containing silicon 0.26% and sulphur 0.34% show the wide range which he covers. He also makes suggestions on the best methods for obtaining special properties in the castings such as strength, or ductility, or machinability. His discussion on the effect of different shapes of graphite, including the notch effects, is particularly good. He brings out the point that the nodular form of graphite in malleable does not favor the penetration of gases, that the tendency of malleable toward growth is far less than that of ordinary cast iron, and that the addition of inhibitors prolongs the life of malleable castings under high temperature conditions. (In another section he states that such inhibitors are also used for the prevention of graphite in heavy sections before the annealing operation.)

Numerous references are made throughout the text to a bibliography, covering one hundred references. As this book will doubtless be used mostly for reference work, it is unfortunate that an index is not included.

Old Man Corrosion

Corrosion Resistance of Metals and Alloys, by Robert J. McKay and Robert Worthington. American Chemical Society Monograph Series No. 71. 462 pages, 6x9 in. Published by Reinhold Publishing Corp., New York. Price $7.00.

Reviewed by J. J. Kanter
Crane Co., Chicago

This valuable work comprises a worthy addition to that series of monographs on chemical subjects of which it is a member. As is characteristic of these books produced under the auspices of the American Chemical Society, the authors are particularly qualified through experience and professional connection to give an authoritative and comprehensive treatment to the difficult subject of metallic corrosion. Theirs is perhaps the first book to appear giving a concise assembly of corrosion information for the entire range of metals and alloys, ferrous and non-ferrous, of technologic importance. The stated purpose of the work, appearing in their preface, "to summarize the facts on corrosion and processes and rates" has been skillfully achieved. A quick appraisal of the present state of knowledge of alloy corrosion is most satisfactorily afforded with this new book at hand. Thus its value in helping to judge the proper choice of alloys is apparent.

The volume consists of two parts. The first is a treatment of the general and theoretical aspects of corrosion such as rate factors, types and forms of corrosion, classifications of corrosive media and the metal corrosion properties. This section is a most readable presentation of the modern physical-chemical views on the general causes and inhibition of corrosion. A rational understanding of the possibilities and limitations in the combating of corrosion and the handling of media is perhaps the most effective approach to the whole subject. With such a theoretical background the authors introduce the second part of the subject — a detailed consideration of the corrosive behavior of specific metal and alloy groups with respect to the various media and conditions of service to which they are exposed.

Individual chapters are devoted to specific metals widely used as alloying bases. In each such chapter is treated the group of alloys or protective coatings implied by this "key" metal. These alloy groups include magnesium and its alloys, aluminum and its alloys, zinc and zinc coatings, cadmium plate, tin and tinplate, lead, iron and steel, silicon-iron, molybdenum alloys, chromium alloys, chromium plate, nickel-iron alloys, copper and the high copper alloys, brass, bronze and nickel silver. Appended to each such chapter appears a bibliography, enhancing the utility of the book as a guide to other literature. Charts, diagrams and tables are profusely used and add to the effectiveness of the data presentation. Since metals rather than media form the foundation of presentation, one is compelled to make copious use of the subject index in locating information on suitable materials for applications to specific media and conditions. The completeness of the indexes bespeaks the authors' realization of this problem.

The vast economic waste wrought by corrosion is subtly kept before the reader by a series of whimsical sketches, initialed R.W., appearing at odd spots throughout the volume, depicting the diabolical exploits of "Old Man Corrosion." His career is followed in epic fashion from the frontispiece where he embarks upon a crusade of destruction to closing page where the efforts of science and industry have finally accomplished his demise!

Personals

Gilbert E. Doan ⊕, associate professor of metallurgy, Lehigh University, has been advanced to the position of professor of metallurgy.

Warner S. Hays has been made managing director of the American Welding Society.

Frederick M. Becket ⊕, president of Union Carbide & Carbon Research Laboratories, Inc., has been awarded the Acheson medal of the Electrochemical Society.

Col. Glen F. Jenks ⊕ has been transferred from Watertown Arsenal to the Office of Chief of Ordnance, U. S. Army, Washington, D. C. He is chief of the technical staff of the Ordnance Department.

Albert J. Dornblatt ⊕ has accepted a research associateship at the National Bureau of Standards, Washington, in the employ of The American Metal Co., Ltd. of New York.

John Ward Bolton ⊕, Lunkenheimer Co., Cincinnati, has been awarded the John A. Penton medal of the American Foundrymen's Association. **James T. MacKenzie** ⊕, American Cast Iron Pipe Co., Birmingham, has received the J. H. Whiting medal, and **Charles Willers Briggs** ⊕, U. S. Naval Research Laboratory, Washington, D. C., the William H. McFadden medal.

J. R. Heckman ⊕, for the past five years manager of the Chicago district of The Midvale Co., has resigned to become district manager of the General Alloys Co. in the same territory. **J. C. Glass** ⊕, associated with The Midvale Co. for the past 17 years in the Cleveland district, will succeed Mr. Heckman.

R. J. Perry ⊕, formerly tool hardener for John Deere Harvester Works, is now with Nordberg Mfg. Co., Milwaukee, in the same capacity.

Maurice L. Pinel ⊕ is now instructor in metallurgy at Columbia University. He was previously research assistant in physical metallurgy.

Fred L. Spangler ⊕, formerly metallurgist at Hamilton Watch Co., has accepted a position with Leeds & Northrup Co. in the Market Extension Division.

W H. Steinkamp ⊕ has been transferred to Buffalo as industrial manager, Brown Instruments Division, Minneapolis-Honeywell Regulator Co.

H. Y. Bassett ⊕ is now employed by Surface Combustion Corp., Toledo, as sales engineer specializing in the non-ferrous field.

Shock-resistant

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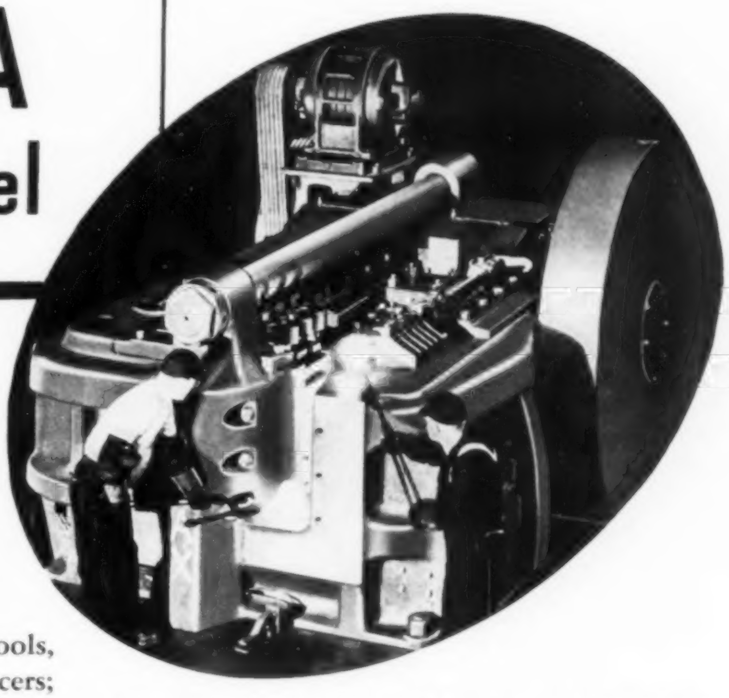
Hot Work Steel



● Wherever a tough tungsten hot work steel is needed to withstand extreme shock and sudden temperature changes, Atlas A is recommended. If water cooling is to be used, Atlas A will stand up under service conditions of this kind better than Mohawk or Atlas B. It has a good red hardness and is hard wearing.

Atlas A is recommended for hot nut tools, such as crowners, cut-offs, side dies, and piercers; also for punches and dies subject to severe shock and temperature changes.

DATA ON ATLAS A

Typical Analysis

C.	.30
W.	9.00
Cr.	3.50
V.	.45

Treating Ranges		*Hardness Ranges*	
Forging	2000-1600° F	Annealed	207-228 Br.
Annealing	1550-1600° F	Forged	450-500 Br.
Hardening	1950-2150° F	Quenched	50-53 Rock. C
Quenching	Oil or Air	Drawn	40-47 Rock. C

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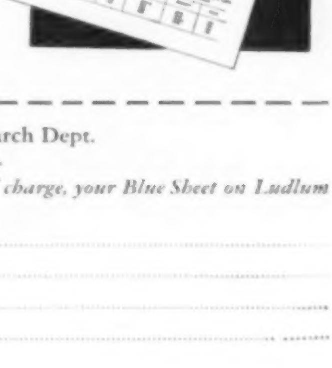

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Address ....

....

Personals

Carl G. Werscheid ⊕ is now connected with the St. Louis office and warehouse of the Ludlum Steel Co.

K. W. Grant ⊕ has been transferred to the Corrigan-McKinney plant of Republic Steel Corp. at Cleveland as chief inspector.

Elmer Gammeter, vice-chairman of the Chicago Chapter ⊕, and for the past six years metallurgist for the Edison General Electric Appliance Co., has joined the Alloy Division, Metallurgical Department, Carnegie-Illinois Steel Corp., Chicago.

J. P. Morrissey ⊕ has been appointed head of the Weld Rod Sales Division of the Harnischfeger Corp. of Milwaukee.

H. O. Hartdegen, sales engineer, is taking charge of the northern New York and eastern Pennsylvania territory for Driver-Harris Co. **J. B. Shelby** ⊕, formerly in charge of this territory, has been advanced to the management of the Foundry Division, where he will act as co-manager with **Joseph Sammon** ⊕.

Dwight V. Hall ⊕ has been promoted to supervisor of all heat treating operations for Douglas Aircraft, Inc., Santa Monica, Calif.

C. Kondy ⊕ has left Swedish Crucible Steel Casting Co., Detroit, and is now with St. Louis Steel Casting Co. as metallurgist in charge of melting.

Paul H. Setzler ⊕, formerly development engineer for The Lincoln Electric Co., has taken a position as production manager of Lukenweld, Inc.

Ralph L. Manier ⊕ has been appointed to the Central Division Staff of the Niagara Hudson Power Co. **S. W. French** ⊕ succeeds Mr. Manier as industrial heat engineer for the Syracuse Lighting Co., Inc., Syracuse, N.Y.

L. J. Reay has been appointed president of the Mahr Mfg. Co., Minneapolis.

C. H. Joy has been appointed sales representative in the Pittsburgh district for Wheelco Instruments Co.

R. J. Southwell has been appointed sales manager of Andrew C. Campbell Division of American Chain & Cable Co., Inc., Bridgeport, Conn.

Albert L. Galusha has become associated with The Wellman Engineering Co., Cleveland, as chief engineer of its recently acquired line of Galusha gas equipment.

Paul Schwarzkopf of Reutte, Austria, has accepted the presidency of the American Cutting Alloys, Inc., New York City.

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FOR STRENGTH · TOUGHNESS · DURABILITY

Embrittled Copper

(Continued from page 627) of grain boundary voids. In the next experiment a sample from the same lot of copper was packed in aluminum oxide in a seamless steel tube and heated for the same length of time at the same temperature. This treatment gave a brittle wire and justified the conclusion that the steel tube at least was a source of reducing atmosphere.

In the next experiment copper from the same lot was packed in sea sand in a porcelain tube and heated for one hour at 800° C. This sample proved to be brittle and showed unmistakable evidence of gassing, justifying the conclusion that the sea sand was a second source of reducing atmosphere. When this experiment was repeated, using sea sand which had previously been ignited four hours in air at 600° C. (1100° F.) to remove any organic matter which might be present, and then used as a packing in a porcelain tube the copper specimen remained ductile, indicating that something on the surface of the sand had been responsible for the reducing atmosphere produced when that material was used without preliminary calcination.

To satisfy ourselves that the presence of iron as such had nothing to do with the embrittlement of copper, the following experiment was performed: Tough pitch copper wire from the same lot of material was packed in finely divided aluminum oxide in a tube made from electrolytic iron, which iron contained 0.003% carbon, the tube having been closed by copper plugs at both ends. After having been heated for one hour at 800° C. the copper specimen was ductile, offering further proof that it had been the carbon in the seamless steel tube which was responsible for at least some of the reducing condition.

These experiments, in the opinion of the author, serve to emphasize the fact that a very small amount of reducing atmosphere can, with the proper conditions, produce embrittlement of tough pitch copper. Some cases where such embrittlement has more or less frequently been found (and it is to be hoped less rather than more frequently) are brazed joints and enameled wire. Such embrittlement can, of course, be avoided by the use of copper which contains no oxygen, now a commercial product.

Induction Furnace

(Continued from page 621) If the crucible should actually break through, the damage to the copper furnace coil will necessarily be smaller than though the metal encountered any iron parts in the furnace shell.

The crucible of this six-ton furnace is given an acid lining for which quartzite is used. It can be prepared either by the Rohn process or the tamping process invented by the Siemens & Halske firm.

According to the Rohn process, the bottom is first tamped in, the copper coils lined with an asbestos jacket, and a sheet metal lining or inner template properly placed. A layer of refractory is then placed, tamped from top and interior (through the template by a pneumatic hammer) and this layer roughened by a pointed iron bar before the next layer is placed. Sintering takes place through the template which is slowly heated by induction; it finally becomes hot enough to melt.

According to the tamping process patented by Siemens, a pneumatic tamper rams in a mixture of moistened quartzite of graded sizes, mixed with small quantities of binder (dry, fine quartzite mixed with boric acid). Interior and exterior templates are used. After finishing, the outer template is removed, and the space between crucible and furnace coil is filled with dry crucible material. After that, the crucible is dried with induced heat by the aid of the inner template, and hardened. This process requires about 1½ hr. After drying, the inner template is pulled out and the furnace is ready for charging.

[Presumably the lower part of the lining is rammed in, the top being built of chamotte brick, protected during the first heat by a thin corrugated metal sleeve. This method is widely used in Europe, although Americans prefer asbestos sleeves, which do not need to be corrugated to take care of expansion — *Editor.*]

Each of the two methods has certain advantages and disadvantages. When made by the Rohn process, the softening point of the crucible is somewhat higher, thanks to the absence of any cement. On the other hand, the Siemens crucible possesses a higher mechanical strength, since coarser granules can be used, and a denser wall built. The labor costs are the same; with skilled crews, from 8 to 10 hr. is required.

Book Reviews

Rosenhain's Physical Metallurgy

An Introduction to the Study of Physical Metallurgy, by WALTER ROSENHAIN. Third Edition, revised and partly rewritten by John L. Haughton. 368 pages, $5\frac{1}{2}$x$8\frac{1}{2}$; 159 figures and plates. D. Van Nostrand Co., 250 Fourth Ave., N. Y. Price $8.00.

Rarely is a technical book so well written, from such a forward-looking viewpoint, and based on such sound reasoning as to exhaust six printings and then warrant republication 20 years later with only minor revisions. That such is true of Rosenhain's Physical Metallurgy is almost all the comment that is necessary.

Shortly before his untimely death in 1934, Rosenhain undertook to revise his book, but the actual work fell upon Dr. Haughton's shoulders. No one short of the original author would be so well fitted for the work, for the two of them were long associated at the National Physical Laboratory, one as Chief and the other as Principal Scientific Officer of the Metallurgical Department. In this time Dr. Haughton had ample time to become acquainted with the thought processes and the views of his chief. It is therefore not a Haughton book, but still remains a Rosenhain book.

The early chapters, having to do with physical testing, have needed small additions except for X-ray spectroscopy which warrants a new chapter. Its utility is clearly shown by a study of the silver-cadmium system, where the method determines the amount of the five phases and the crystalline architecture of each. Practically all of the typical alloy systems cited in the old chapter of that name have been re-examined in recent years, and the new edition contains diagrams including the latest reliable information (strangely enough, the iron-carbon diagram shows no solubility of carbon in ferrite).

Dr. Haughton, in his preface, turns aside expected criticism of the chapter on amorphous theory, saying, "While it might perhaps have been more in accord with the ideas of the majority of metallurgists to have introduced much more drastic alterations, I felt convinced that such alteration would not have been approved by Dr. Rosenhain himself, as he had said to me when we were discussing the question

(Continued on Page 664)

of the place the amorphous theory should occupy in the book, that he believed there was more evidence in its favor now than ever before." In the reviewer's opinion this is well, for he knows no other place where this classical theory is so well and completely stated.

Other theories of hardening are not discussed; in fact, the old edition had a couple of pages on the nature of quenched and tempered steel which are now eliminated, with the suggestion that the interested reader should refer to the able summation by Professor Portevin in the 1933 May Lecture to the Institute of Metals. This is the only serious defect found in the new edition. In the old book, Rosenhain introduces this subject by saying, "The question, 'What is martensite and to what is its great hardness really due?' cannot as yet be answered quite conclusively," and after outlining various theories, gets close to the kernel of the proposition with this sentence: "By rapid cooling, however, the growth of these alpha crystals is stopped at a very early stage and the quenched steel is arrested in a condition in which it consists of numberless minute alpha crystals surrounded by layers of hard and strong amorphous metal and possibly embedded in some unchanged gamma iron." A hit, a palpable hit!

When you remember that Rosenhain wrote those words more than 20 years ago, the greatness of the man and the importance of the book may be judged. E. E. Thum

Construction of Large Openhearths

The Openhearth Furnace, by William C. Buell, Jr. Volume I, 276 pages, 6x9 in., 68 illustrations. Published by Penton Publishing Co., Cleveland. Price $4.15.

Reviewed by Norman I. Stotz
Universal-Cyclops Steel Corp.

For simplicity this book discusses the subject from the viewpoint of the 150-ton openhearth, and the data presented are compiled from an analysis of 16 modern American furnaces of stationary type.

The introduction is unusually well compiled from a historic standpoint. In the chapter on the economics of the openhearth furnace the cost factors are presented in a way that

(Continued on Page 668)

makes them very convincing and valuable not only to furnace operators but also to laymen.

The chapters on refractories and the thermal effects in refractories are timely and should be a valuable contribution to the general field of heat flow, regardless of the purpose of the furnace. This reviewer has never seen a better evaluation and description of the various types of insulating materials.

The main body of the treatise discusses furnace bottoms, back walls, front walls, roofs, mechanics of the roof, skew systems and buckstays in great detail. The completeness and clearness of the illustrations and the tables is worthy of special commendation. Various fundamental equations of construction principles are dealt with rather simply.

All in all it is a practical, sensible book from a practical viewpoint that should fill a valuable place in openhearth literature.

One minor criticism of the text from the standpoint of structure is the tendency to divide the subject matter by sub-headings for emphasis, somewhat like the titles used in newspaper columns. These subdivisions often are not too well placed, since they at times interrupt the sequence of the text and tend to defeat the purpose of emphasis by their abruptness. The text is worthy of more dignity than these subdivisions tend to create.

Arc Welding, Good and Bad

Procedure Handbook of Arc Welding Design and Practice. Fourth Edition. 819 pages, $5\frac{3}{4}$x9 in., 990 illustrations. Published by LINCOLN ELECTRIC Co., Cleveland. Price \$1.50 (\$2.00 abroad).

Reviewed by A. HURTGEN
Henry Vogt Machine Co.

This book is full of information on the rudiments of welding, and its continued sale, edition after edition, is proof that there are a large number of men who are needing just that type of education. As only one case in point, the mechanism of how shrinkage stresses manifest themselves in or near the weld zone is brought out by means of illustrations and experiments which will enable even a layman to visualize just what takes place in the rearrangement of internal

(Continued on Page 670)

Book Reviews

(Continued from Page 668)

loadings while the metal is becoming solid and cooling. These shrinkage stresses are related to the distortion arising from the welding operation, and are of great concern to the success of the job. Skip welding, step-back welding, peening, heat treatment are all described as methods offering a cure for undesirable distortion in certain types of work.

General comments as to welder's qualification tests and suggested methods of checking his ability are also included. The principal important points to observe in inspecting while the work is under way are outlined, such as *(a)* burn-off of electrode, *(b)* the fusion, penetration and crater, *(c)* the formation of the bead, and *(d)* the sound of the arc. Inspection after welding includes the non-destructive methods such as X-ray, electromagnetic, and stethoscopic. Photographs are shown of the visual appearance of welded beads that have been made with both improper as well as proper welding technique.

A very complete and thorough section discusses the economics of welding and gives many tables and charts showing the amount of wire required under various conditions per unit length of joint. General information for the welder and supervisor is included regarding the effects of polarity, elimination of arc blow as well as craters, both of which are very objectionable.

These are only a few of the multitude of items contained in the book, evidently gathered from a wide experience in miscellaneous welding problems met in job shops, repair departments, and production of minor items. When the book gets beyond this field and enters the metallurgy of the operation, the result is not so happy. Probably this is not such a defect as the reviewer may believe it to be, but he is fearful that some of the text (for example) relating to corrosion resistant metal may cause someone expensive disappointment. It may be that those in charge of large and extensive work will separate the wheat from the chaff, but it is hoped that careful editing in future editions will eliminate the most of the errors. Thus, the test bars shown in the chapter on properties of welds are not in agreement with good practice and should be replaced with proper information.

Help Yourself

to this

HELPFUL LITERATURE

Induction Furnaces

A publication of Ajax Electrothermic Corp. tells of the development, operating principles, applications, and advantages of commercial Ajax-Northrup coreless induction furnaces energized by motor generator sets. Also information regarding standard sizes of motor generator sets and furnaces. Bulletin Jr-41.

Coated Electrodes

General information on welding with coated electrodes is supplemented by complete descriptive data on all brands of electrodes manufactured by Metal & Thermit Corp. in a revised edition of their catalog. Bulletin Jy-64.

Alloy Steels

Why alloy steels are best for heavy equipment and other exacting applications is discussed in a folder by Bliss & Laughlin, Inc. A partial list of the more common grades gives machine ratings and turning speeds. Bulletin Jy-42.

Drawing Furnace

A new convected air gas fired furnace for drawing and tempering dense loads has been announced by Despatch Oven Co. Complete details concerning its design and operation, the results obtainable, and prices are given in Bulletin Dy-123.

Locomotive Steels

A comprehensive review covers specific applications, based on current practice, of various types of vanadium steels for locomotive and car construction. It contains 72 pages and is available to railway executives and engineers. Published by Vanadium Corp. of America. Bulletin Dy-27.

Firebrick

Babcock & Wilcox make an insulating firebrick which is refractory as well as insulating and can be used without a facing of firebrick. Description, applications, and engineering data are contained in Bulletin Fy-75.

Temperature Control

Costly overheating of furnace roofs can be prevented by the temperature-limit control described by Leeds & Northrup. Large dial, easy installation, and ruggedness are the features emphasized. Bulletin Dc-46.

Heading and Upsetting

A multitude of unusual parts, beautifully photographed and displayed in a folder by Lamson & Sessions Co., can now be produced by heading or upsetting to close tolerances and with an entirely satisfactory finish. The advantages of bolt-making methods are explained. Bulletin Da-164.

Alcoa Notes

"Alcoa Random Notes" is the intriguing title of a little monthly paper got out by Aluminum Co. of America. A request for this bulletin will bring you a copy of the latest issue. Bulletin Ca-54.

Graphitic Corrosion

The peculiar form of disintegration occuring in cast iron which is known as graphitic corrosion is explained in a reprint of a technical article by Wesley, Copson and LaQue of International Nickel Co. Bulletin Ea-45.

Stainless Steel Facts

Carpenter Steel Co. offers (to manufacturers in U.S.A. only) a booklet, designed in handy file folder form, presenting a wealth of data on Carpenter stainless steels. A good reference source of material. Bulletin De-12.

Gold and Silver Plate

Important information about efficient and economical methods of gold and silver plating with precious metal cyanides is contained in a comprehensive booklet by E. I. du Pont de Nemours & Co. Specific data on equipment and operation are given. Bulletin My-29.

Model "Y"

The Sentry Model "Y" electric furnace, using the Sentry Diamond Block method of heat treatment provides exceptional quality high speed steel hardening at minimum production cost. The furnace is described in Bulletin Oy-114.

Quenching Handbook

E. F. Houghton & Co. have published an excellent 80-page handbook on the subject of quenching. More than 30 charts and photomicrographs help tell the story. Bulletin Jl-38.

Metals for Corrosion

Fourteen varieties of Midvaloy corrosion and heat resisting metals are described in a detailed bulletin by The Midvale Co. Properties and applications are listed and illustrated. Bulletin Ca-160.

Mesh Products

Wire mesh is a class of material about which little is heard. A folder by C. O. Jelliff, therefore, telling the special alloys and metals used, styles of weaves and applications, is of unique interest. Bulletin Da-78.

Corrugated Ingots

The Gathmann Engineering Co. has published a new booklet called "Gathmann Ingot Molds — Their Purpose and Design." It illustrates various corrugated ingot contours designed to produce defect-free surface in steel ingots. Bulletin Ay-13.

Electric Salt Baths

Literature is available from Bellis Heat Treating Co. describing electrically heated bath furnaces which are economical to operate and have a wide range of applications in hardening, annealing, and heat treatment of high speed steel, stainless steel, nickel, aluminum, copper and bronze, etc. Bulletin Ny-48.

Testing with Monotron

Shore Instrument & Mfg. Co. offers a new bulletin on Monotron hardness testing machines which function quickly and accurately under all conditions of practice. Bulletin Je-33.

Moly Matrix

Climax Molybdenum Co.'s little monthly newspaper contains many interesting and informative articles. Get the latest issue—Bulletin Ax-4.

X-Ray Examination

The application of X-ray examination and inspection of castings, welding, and food products, as well as practical X-ray crystal analysis, is completely described and strikingly illustrated in General Electric X-Ray Corp.'s new 34-page publication. Bulletin Dy-6.

Magnet Steels

A very handsome booklet describes the permanent magnet steels and castings made by Simonds Saw & Steel Co., including Alnico and Alnic. Bulletin Ba-158.

Copper Welding Rods

American Brass Co. describes in complete detail the welding properties and individual characteristics of 14 different copper alloy welding rods. The 16-page booklet also makes specific recommendations of welding procedure. Bulletin Je-89.

Hardening Furnaces

P. D. M. high speed hardening furnaces are described in two bulletins by The Philadelphia Drying Machine Co. — one devoted to oil-fired and one to gas-fired furnaces, both made in single and twin chamber models. Details of construction, design features and tables of sizes and capacities are included. Bulletin Oy-150.

Globar Elements

Globar electrical heating units and a variety of accessories for their operation have been catalogued by Globar Division of Carborundum Co. Bulletin Oy-25.

Hy-Speed Case

A striking and interesting new booklet on Hy-Speed Case has just been published by the A. F. Holden Co. Typical applications and results are cited. Bulletin Fa-55.

Flame-otrol

The "Flame-otrol," a safety device developed on the Wheelco radio principle is described in a folder by Wheelco Instruments Co., which includes diagrams and price list. Bulletin Fa-110.

Malleableizing

A folder by Surface Combustion Corp. on the use of the radiant tube heating element for malleableizing cast iron, contains a reprint of an Iron Age article by Carl F. Joseph. Diagrammatic view and description of the element are included. Bulletin Fa-51.

Abrasive Cleaning

Comprehensive information on airless abrasive metal cleaning is contained in a new book on the "Wheelabrator" Tum-Blast, a patented mechanical device made by the American Foundry Equipment Co. Bulletin Fa-112.

Electric Tempering

The American Electric Furnace Co., model AO-1 is an ideal unit for tempering individual pieces or production quantities of small parts up to 1200° F. Described in Bulletin Fa-2.

Welding Instruction

A complete training school in arc welding is maintained by the Lincoln Electric Co. in Cleveland. A complete description of the course including duration, registration and fees is given in an illustrated booklet. Bulletin Fa-10.

Hot Work Steel

A new "Blue Sheet" by Ludlum Steel Co. gives physical properties, comprehensive test data and recommendations for heat treating Atlas A hot work steel, a tough, shock resistant tungsten steel. Bulletin Fa-94.

Radiation Tube

The Pyrometer Instrument Co. has a super-sensitive radiation tube for high temperature readings where thermocouples are unreliable or too expensive. This rapid recorder is described in Bulletin Fa-37.

Insulag

A new development in plastic refractory lagging for temperatures up to 2200° F. is described in a bulletin by the Quigley Co. Properties, uses and instructions for applying are included. Bulletin Fa-139.

Spectrometry

A chapter on basic theory and design of spectrometers or spectrographs explaining the principle of operation in full detail precedes a catalog of spectrometric equipment by Bausch & Lomb Optical Co. Bulletin Fa-35.

Some of the Best Thinking

in the metal industries is at your disposal in the literature described here. One booklet may hold the key to your current problem. Help yourself to this helpful literature. It's free. You incur no obligation when you return the coupon.

Thermometers

A complete catalog and price list with excellent illustrations covers all manner of thermometers and hygrometers, made by C. J. Tagliabue Mfg. Co. Bulletin Fa-62.

Copper Bulletin

A new clearing house for news of developments in brass, bronze, and copper, the "Copper Alloy Bulletin," issued by the Bridgeport Brass Co., made its appearance with the March issue. It is edited for the technical and engineering audience. Bulletin Da-163.

Grinding Carbide

A handbook has been prepared by Norton Co. to assist toolroom operators in selecting the proper grinding wheels for use on cemented carbides, which require entirely different tools and technique from high speed steel and stellite. Bulletin Fa-88.

Stainless Uses

Excellent illustrations and interesting text tell of the wide variety of applications of chromium stainless steels in practically every industrial field. Electro Metallurgical Co. Bulletin Fa-16.

Rolling Temperatures

Particularly applicable to rolling mill temperature measurement is Bristol Company's "Electronic Instagraph" by means of which temperatures can be measured while the steel is in motion. Bulletin Fa-87.

Bolts and Nuts

The calorizing process of driving aluminum into the surface of steel and the physical properties of bolts and nuts made from calite alloys are described in a folder by the Calorizing Co. Bulletin Fa-26.

Toolmakers' Microscope

Only recently have optical methods of measuring and testing been introduced in the workshop. These methods — particularly adapted to measuring small and intricate parts — and the equipment used are fully described in a booklet by E. Leitz, Inc. Bulletin Da-47.

Insulation Service

"Barriers to industrial waste" is what Johns-Manville calls insulating materials. A small 64-page booklet catalogs their complete line, which contains a product for every temperature. Bulletin Da-100.

Turbo-Compressors

Spencer Turbine Co. has turbo-compressors in all sizes and types for oil and gas-fired furnaces, ovens and foundry cupolas. Special types for special purposes such as gas-tight and corrosion resisting applications are also described in Bulletin Da-70.

Berryllium Copper

A reference work of new and up-to-date information on the unusual characteristics of beryllium copper contains helpful data on production, fabrication and heat treatment. Riverside Metal Co. Bulletin Fa-156.

Diamond Wheels

A striking presentation is made by the Carborundum Co. in a 52-page booklet on diamond wheels. Detailed technical information is contained and a price list attached. Bulletin Ca-57.

Hydraulic Tester

Of interest to all engineers recommending or purchasing universal testing machines is a book by Riehle Division of American Machine and Metals, Inc., on the development of the precision hydraulic testing machine. Bulletin Ba-157.

New Joining Process

Metal parts are joined cheaply, neatly and strongly by Electric Furnace Co.'s new, inexpensive non-oxidizing furnace atmosphere and their new, continuous brazing, coppering and soldering furnaces. Full details are given in Bulletin Ar-30.

Spectrum Analysis

The elements of both qualitative and quantitative spectrum analysis are contained in a handy booklet by Carl Zeiss, Inc. A price list covering all equipment is included. Bulletin Da-28.

Meehanite

A compact but complete specification chart gives the recommended grades of Meehanite metal for various service requirements. Complete physical properties and applications are included. Bulletin Da-165.

Alloy Castings

Michiana Products Corp. has published a new book describing Michiana corrosion resistant and stainless steel alloys. Generously illustrated, it suggests many savings for the use of these alloys. Bulletin Oy-81.

Laboratory Service

A new edition of "The Metal Analyst" tells about an organization established by Adolph I. Buehler specializing in the installation of metallurgical laboratories. The complete line of laboratory equipment marketed by Buehler is also catalogued. Bulletin Dy-135.

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in Bulletin D-17.

Stress-Strain Recorder

The many applications of the Baldwin-Southwark stress-strain recorder, its unique advantages, and the many ways it can give unusual service will be extremely interesting to all who have to do with testing methods and equipment. Bulletin Ba-67.

Nickel-Copper Steels

Exceptional resistance to corrosion and abrasion, increased tensile strength, and higher ductility are the qualities claimed for Youngstown Sheet & Tube Co.'s new series of Yoloy steels. A summary of properties and notes on their characteristics are contained in Bulletin Ox-93

Centrifugal Castings

Centrifugal casting of stainless, heat and corrosion resisting alloys eliminates impurities and cooling strains and permits thinner and more uniform walls than any other method. This is explained in a bulletin by Michigan Steel Casting Co. Bulletin Nx-84.

Photo-Electric Cells

If you are not familiar with the wide field of applications for photo-electric cells and apparatus, send for this very interesting and complete booklet by Pfaltz & Bauer, Inc. covering the original apparatus developed by Dr. Bruno Lange. Bulletin Ca-142.

Testing Machines

An extremely handsome, spiral-bound, segregated catalog tells all about the various hydraulic and screw power testing machines made by Tinius Olsen Testing Machine Co. Bulletin Oy-147.

Stainless Data Book

All users of stainless and heat resisting alloys should find invaluable the information contained in a booklet published by Maurath, Inc. giving complete analyses of the alloys produced by the different manufacturers, along with the proper electrodes for welding each of them. Bulletin Jy-125.

Liquitol

The use of Liquitol for controlled cooling of iron and steel castings and ingots is fully described in a bulletin by Alpha-Lux Co., Inc. Bulletin Ma-120.

Port Valves

Diagrams and descriptive matter show the operation of adjustable port valves made by North American Mfg. Co. that are particularly suitable for mediums whose rate of flow is not constant Bulletin Oy-138.

Newer Tool Steels

Vulcan Crucible Steel Co. has a complete and attractive catalog listing their full line of tool steels including many special types to meet the modern trends in industry. Bulletin Jy-127.

Resistance Wire

A complete catalog of the various types of electric resistance wires made by Hoskins Mfg. Co. has been issued. Complete numerical data are included on all types, along with some fundamental facts about heating units. A handy, small size 48-page booklet. Bulletin Jy-24.

Cleaning Rooms

A catalog of designs for blast cleaning rooms incorporating many labor and time saving improvements making the blast room an unequalled mechanical device for low cost cleaning is published by Pangborn Corporation. Bulletin Ca-68.

Ni-Cr Castings

Compositions, properties, and uses of the high nickel-chromium castings made by The Electro Alloys Co. for heat, corrosion and abrasion resistance are concisely stated in a handy illustrated booklet. Bulletin Fx-32.

Dust Collector

How the Schneible multi-wash dust and fume collector operates and what it does are clearly shown in a catalog giving details on existing installations. Published by Claude B. Schneible Co. Bulletin Ca-161.

Metal Progress,
7016 Euclid Avenue, Cleveland, O.

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	Ay-13	Fa-55	Fa-35	Da-70	D-17				

Helpful Literature

(Continued from page 673)

Tool Room Furnace

A new type of lining and one-valve control are two of the features of the American Gas Furnace Co.'s new tool room oven furnace that would make it economical to replace many older furnaces now in operation. Fully described in Bulletin Ox-11.

Cutting Oils

The problems of machine tool lubrication engendered by the high speed production and close tolerances of modern industrial operations are discussed and progress in cutting oils during the past few years reviewed in a booklet by D. A. Stuart & Co. Bulletin Jy-118.

Rustproofing

How the Detrex method of solvent degreasing provides the advantages of speed, economy, and satisfactory cleaning before all kinds of rustproofing and finishing operations is pointed out in a leaflet by Detroit Rex Products Co. Bulletin Dy-111.

Metal Heating

Improvements in furnace economies, operating conditions and appearance, furnaces that will more satisfactorily meet old requirements or handle new processes, service that will help solve the most stubborn problems are offered and described by Mahr Mfg. Co. in Bulletin Ea-5.

Air Weight Control

An illustrated booklet of sure-fire interest to the foundry trade has been issued by The Foxboro Co., explaining in detail the advantages of the "air weight controller" which is in use at many of America's leading foundries, named in the publication. Bulletin Ea-21.

Furnace Control

How the Lindberg Control functions in balancing the rate of heating of a furnace or oven with the varying heat requirements is told in an attractive new bulletin issued by Lindberg Engineering Co. Bulletin Nv-66.

Alloy No. 10

A high temperature muffle furnace, the first of the Hevi Duty line of laboratory furnaces equipped with Alloy No. 10 allowing working temperatures to 2400° F., is described in Bulletin Jb-44.

Oxidation

Designers confronted with oxidation problems connected with cracking coils, polymerization plants, superheaters, high pressure steam plants, air heating equipment and recuperators will welcome a folder by Timken Roller Bearing Co. containing data on oxidation at 1000, 1250 and 1500° F. Bulletin Ea-71.

Tocco Process

This amazing new and extremely accurate method of heat treating is described in a new four-page leaflet, yours for the asking. Distributed by Ohio Crankshaft Co. Bulletin Oy-145.

Flux

A short, informative bulletin covering the low melting temperature, rapid solvent action and wide temperature range of Handy Flux—which speeds up and improves brazing operations. Handy & Harman. Bulletin Oy-126.

Calculator

A handy gadget is a sliding weight calculator which can compute weights per lineal inch of steel for 161,200 cross-sections. Pocket-size, it contains tables for rounds, hexagons, octagons, squares and flats. Distributed by Heppenstall Co. Bulletin Ea-122.

Sheet Metal

One of the most modern of the current pieces of industrial literature dealing with sheet metal is Republic Steel Corp.'s "The Path to Sheet Metal Permanence," a 20-page booklet of useful information containing more than 60 interesting photographs. Bulletin Ea-8.

Rockwell Tester

A revised and completely up-to-date catalog on the well-known Rockwell hardness tester is well illustrated and containes 24 pages. Published by Wilson Mechanical Instrument Co., Inc. Bulletin Ca-22.

Rails

"Brunorizing" is a new method of producing an improved steel rail for today's heavier and faster trains. A nicely printed and well illustrated 24-page booklet by United States Steel Corp. explains the process thoroughly. Bulletin Ea-79.

Sheet Containers

The mechanical and thermal requirements peculiar to sheet carburizing boxes are explained in an illustrated folder by Driver-Harris Co. describing this particular type of equipment in detail. Bulletin Ea-19.

Safety in Oxwelding

A revised edition of "Precautions and Safe Practices" in the care and handling of oxy-acetylene equipment has been prepared by The Linde Air Products Co. This booklet is regarded as a standard reference on this phase of safety in industry and this latest edition contains some new suggestions required by advances in the oxy-acetylene process. Bulletin Mx-63.

Brass Strip

(Cont. from p. 634) puckering, according to the stresses set up); and *(c)* the formation of ears.

Dealing with the first of these manifestations, the modern tendency in deep drawing is to utilize the full capacity of sheet for deformation. If, due to marked directionality, the physical properties of sheet fall below a certain fairly high standard even in certain directions, failure will occur. It is particularly interesting to observe that the splits *always occur at approximately 45° to the direction of rolling.* It is hard to convince a user that this is due to defects in his forming tools or some other shop condition.

Regarding the second manifestation, uneven flow in tools, this effect will be most marked in large articles; but even in small, complicated articles it is common practice to use blanks of rather irregular shape in an attempt to accommodate localized flow. The present practice of orienting blanks solely with regard to the conservation of metal in the strip form may not produce blanks having maxima and minima lying in the optimum position for the shaping of any given article.

The third manifestation, that of ears, is frequently not in itself detrimental unless the height of the ears is considerable and the size of the blank barely adequate. The point is that marked ears indicate the presence of *thinning* in the walls in line with them. They can, therefore, be regarded as a useful warning to the practical operator that all may not be well with the shells he is producing. It is, of course, desirable in mass production to produce a cup that will not need to be trimmed on its top edge.

Directional properties in thin sheet may easily be demonstrated by a tear test. For this, a sample of the sheet has short flaps ¼ in. wide cut and turned up square at various places around the edge. One after another they are then wound around a slotted key, exactly as one opens a can of sardines. The length of the tear so made, while doubtless representing the combined effect of more than one property of the sheet, will be approximately equal in sheets with minimum directional differences, and markedly various in sheets that have distinct directional properties.

HOUSE ORGAN OF QALLOYS "To Be Sure" GENERAL ALLOYS COMPANY

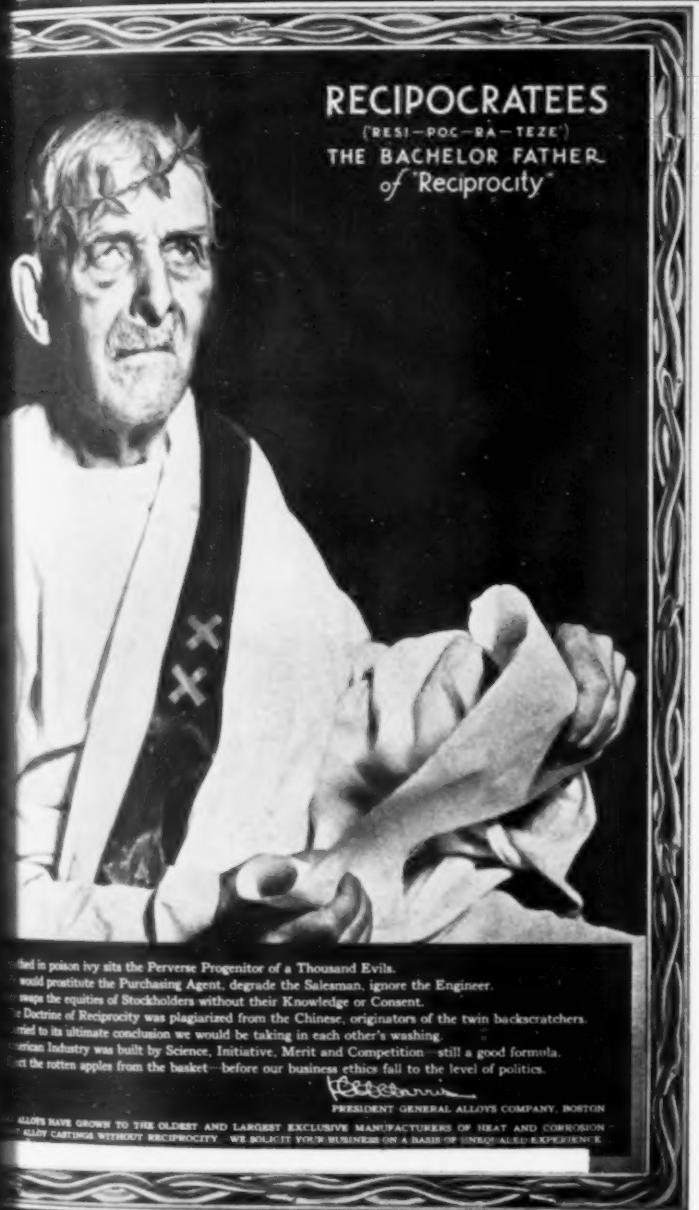
EDITED BY [signature] PRESIDENT

ALLOY PROGRESS

Bright Spot in Metal Progress

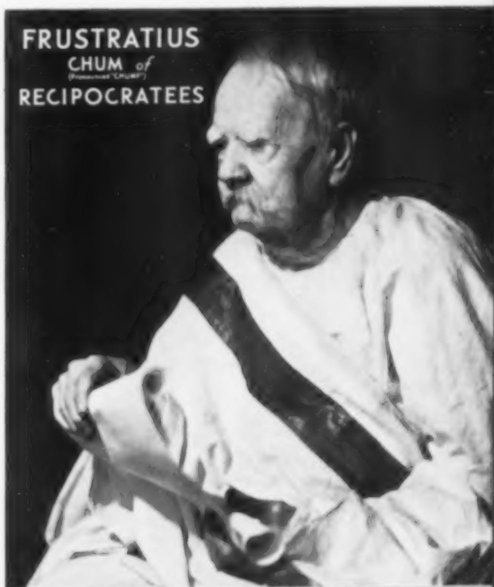
ENTIRELY ABOUT HEAT & CORROSION RESISTANT ALLOY CASTINGS

Vol. 4 No. 6



SWAMPED!

BY RECIPOCRATEES



In our advertising, as in our Alloys, we strive to transcend mediocrity, but we were unprepared for the howl of acclaim that greeted "Recipocratees," unveiled in Metal Progress, Steel, Iron Age, Chem. & Met., and other publications. Requests were received for more than three thousand copies, many lauding us for our "Crusade against Reciprocity." Fact is, we're not "Crusading" against anything. Life is too short to carry torches. But, boy, *what a Torch!*

Recipocratees is failing with returning prosperity, he's not quite his old self. Below left, you see him in full depression vigor. An interesting character study. Had a lot of stuff on the ball—the 8 ball.

FRUSTRATIUS ➤

Meet Frustratius, Recipocratees' Chum, (Pronounced "CHUMP," the P is not silent as in swimming). If frustration brought on his reciprocity, or reciprocity rung up his frustration, is unknown. Frustratius was the HUMAN RUBBER STAMP, sometimes mislabelled "Purchasing Agent," "Engineer" or "Salesman." His Master does not believe that a keen, unfettered Purchasing Agent is the Guardian of Quality, Efficiency, and Economy, that the goal of all Science and Engineering is TRUTH, that a true salesman is a Disciple of Progress.

In the upper, depression photo, he dared not lift his feeble eyes from the swap-sheet. But, eventually, even he got a belly full of Reciprocity. Now that Business is picking up, He can look 'em all straight in the eye and tell Recipocratees to "Go to Hell," *and—does he love it!*

QALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite

ALL MALLEABLE IRON

HERE you see malleable iron that is *all malleable*, free from surface decarburization, commercially scale free. Uniform to the surface, it machines much easier than the old fashioned kind. The Wagner Malleable people, at Decatur, Ill., are turning out this top quality product in a new SURFACE COMBUSTION CORPORATION radiant tube, controlled atmosphere furnace. This furnace reduces the malleableizing cycle, depending on the silicon content, to from 16 to 32 hours total time in furnace, no boxes, far lower cost per ton. No smart malleable man will ignore it. If alloy tray and rail maintenance cost means anything, he won't ignore General Alloys either.

RECIPOCRATEES—etc.

MOST of our readers in the automotive industry, which led the country out of the depression with value, quality, service, have never encountered "reciprocity." This is a species of racket where a large steel user hires an "Alloy Expert," opens an "Alloy Department" and then uses his steel orders to club alloy business out of the steel companies. Can you imagine the Automobile Companies buying complex alloys or tools, on which production depends, on the basis of which alloy or tool manufacturer can buy the most automobiles? That's like measuring the well by the length of the pump handle.

"RECIPOCRATEES" is no "Campaign" or "Crusade." We just unveiled the old bugger as a gentle reminder to a lot of Buyers, Engineers, and Executives in the Steel, Oil, and other industries with swapadiddle buying policies that, THE DEPRESSION IS OVER, they are now BUSY ENOUGH to NEED the higher QUALITY, more DEPENDABLE products of General Alloys Company.

MOST Purchasing Agents, Engineers and Salesmen, even those compelled to practice ruthless reciprocity, despise the practice. (Write on your letterhead for a picture of "Recipocratees" suitable for framing.)

THERE is very little new about streamlining, the merits of which have been proven for a generation. "999," The Streamline Baker Racer, is reproduced from the Sept. 8, 1904, issue of the Motor World. It made one mile in 60⅗ seconds at Ormond Beach, Florida, with a ¾ H.P. electric motor run from 12 cells of batteries.

WE are happy to announce the Connection of John R. Heckman with

General Alloys, as of May 15th, in the capacity of District Sales Manager. He will have charge of the Chicago Territory, with the exception of the activities of Mr. J. J. Donnovan. John Heckman has been Chicago District Manager for the Midvale Company for the past five years, has an excellent engineering background. He is an experienced Pilot and will use his own Fairchild airplane for transportation, carry my veteran Skyview camera.

ROSEWARE INC.
SURE-STRIKE INC.

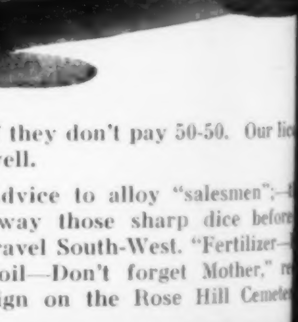
UNDER the "Sure-Strike Inc." Sign, in Milwaukee last week, pickets walked. At Vandalia, O., Dayton's Airport, the W.P.A. boys went on strike for less work, more pay. The first seemed impossible. The field restaurateur said a couple of agitators dropped in, were working up the strike for days, local authorities were "not interested." Tar and feathers have gone with the Hoss'n buggy

days. A Relief Client from D
attended the Coronation.

THE swarthy proprietor of
leased slot-machines yawned
griped about the opening of the
mer season, and the pick-up of
ness. "Gees, I been up alla d
plugga da Jack Pots on zem ma
so he no break for de suck
Summer the machines are set t
15%, for the city trade, bu
"Rubes" won't play 'em in the

if they don't pay 50-50. Our lic
well.

Advice to alloy "salesmen";—
away those sharp dice before
travel South-West. "Fertilizer—
Soil—Don't forget Mother," re
sign on the Rose Hill Cemete



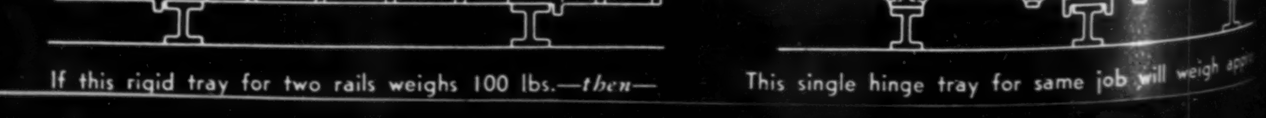
Chicago. Signs brings laughs
over St. Louis Gas Station "C
McDermott." I thought it the
war influence on a local ill
when informed it was not in
as "Chateau," that "Chotea
old name in Missouri.

NAVY Specifications for Corr
Resistant Alloy stump a lot
called alloy manufacturers. So
General Alloys two to three to
of free machining Super St

(Continued on Page 7)

IF YOU USE ALLOY TRAYS IN FURNACES—WRITE FOR DATA ON OUR LIGHTWEIGHT HINGED TRAYS.
(See border this page and page 7)

CHECK THESE SAVINGS



SKYVIEW SUPPLEMENT NO. 1

SKYVIEWS OF DETROIT INDUSTRIES

INCLUDING SOME UPSTATE PLANTS

ese snapshots were taken one windy January afternoon, and one indifferent afternoon, the Saginaw and Bay City shots between five and six thirty, a $3\frac{1}{4}$ by $4\frac{1}{4}$ Skyview Aerial Camera.

ying an airplane and operating a camera simultaneously is not conducive ood photography. Our claim for your consideration will have to rest on proven records of the longest life heat-resisting alloys in Detroit, the st Alloy installations, and the Lowest-Cost-per-Heat-Hour.

oke conditions make Detroit difficult to photograph from the air. When enough to get plants nearly a mile long in focus, haze obscures detail. photographs must be taken on the windward side of town, with a wind g enough to remove smoke, so I offer apologies to our many friends whose s are not included in this supplement. We hope to publish them later.

ish I could convey to you the kick I get from surveying from the air those s with whose growth we have been so humbly, yet so certainly identified.

Largest Carburizing Box and tray installations in Detroit are
Longest Life Alloy installations in Detroit are
Lowest Cost-per-Heat-Hour installations in Detroit are

Q-ALLOY

SKYVIEWS OF DETRO

CHRYSLER HIGHLAND PARK

GENERAL MOTORS FISHER & NEW CENTER BLD

CHEVROLET GEAR & AXLE

HEAT TREATING CONTAINERS · POTS · TRAYS

The modern mechanical furnace made accurate volume heat-treating possible. 8 out of 10 of the pre-depression mechanical furnaces in Detroit were equipt with General Alloys' Q-Alloy and X-ite mechanical parts, most of them are still running, with alloy service records of seven to fifteen years.

During the Depression price buying was in vogue. Price sellers could always match price buyers. Furnace builders, to meet price competition, bought alloy on price, from alloy makers whose products enjoyed little or no standing in the Detroit market. The "Cheap" alloy man has nothing to contribute, mechanically, metallurgically, or in service economies. His product lacks that absolute dependability so essential to maintained pro-

CHRYSLER JEFFERSON AVEN

HUDSON CENTER CONTINENTAL MOTORS RIGHT

BURROUGHS

THE FOOTPRINTS OF GENERAL ALLOYS

GA X-ITE · Q-ALLOYS · GA · Q-ALLOYS · GA

AND CIRCUS PARK

GREAT LAKES STEEL

ALLOY FURNACE MECHANISM

duction. His quality, representation, adjustment policies vary with the times. The Furnace Builder only guarantees his product for a year. Long years after his guarantee has expired, and you've probably switched furnace builders, the General-Alloys mechanical parts are still functioning, and you can get immediate service from General Alloys' Detroit Office, in charge of "Al." Grinnell for 18 years. *Specify "General Alloys Alloy Parts" on your next furnace, and get those extra years of service, with little or no additional cost.* We have many new developments in furnace mechanisms which you should know about, consult us before you buy that next furnace. If you think our claims extravagant, we'll show you the alloy in service.


MOUTH


PACKARD


BRIGGS BODY AND MOTOR PRODUCTS


DODGE FORGE

BECOME THE PATH OF AN INDUSTRY

GA X-ITE GA Q-ALLOYS GA X-ITE GA Q-ALLOYS

PONTIAC · FLINT · SAGINAW and BAY CITY

A few "Up-State" Automotive Plants, in Pontiac, Flint, Saginaw, Bay City, unfortunately restricted in number because of limited space.

We will gladly supply reprints of this SKYVIEW SUPPLEMENT NO. 1 to any Member of A.S.M., or to anyone writing on his company letterhead.

If your plant is shown in these pages, and you are a Member of American Society for Metals, or a plant executive, we will send with our compliments an 8 by 10 photograph of your plant suitable for framing.


CHEVROLET PARTS SAGINAW


CHEVROLET BAY CITY


BUICK FL


PONTIAC


CHEVROLET FLINT


CHEVROLET FOUNDRY SAGINAW


SAGINAW MALLEABLE G. M. C.

...g from .04 to .06 carbon have ...made for jobs ranging from ...rine conning-tower rings, to ...les with the hinges and bolt ...cast integral. Inherently clean ... is the outstanding character... ...f General Alloys foundry-prac... ...oupled with an accuracy to di... ...on "beyond reasonable expec... ..."

...von Hindenburg Zeppelin trag... ...as surprising only in that it ...o long delayed. A friend of ... who crossed in her wired, ... me luck, I'm riding the biggest ... ever built."

...iend, the late General, Sir Sef... ...ranker, who commanded Bri... ...ir forces during the war, was ...tor of Civil Aviation when he ...is death in the tragic wreck ...fire of the British Dirigible ... Affectionately known as ...ky," his visit to America and ...eturn visit in London, bring ... memories. Seated in Gertrude ...nce's dressing room in a De... ...heatre, his high power monocle ...g nothing, he was arguing air... ... with Carl Fritsche, Promoter ...troit's All Metal Dirigible. "But ...hip with hydrogen will fly ... with the same load than ...rican Helium ships," said ...ky." "Admitted," said Carl, ... one spark they will fly much ...."

...he ripples in water at bottom ...s picture.

THE LONGEST SUPREME COMBUSTION MUFFLE

This gas-tight muffle is the "Guts" of the longest gas carburizer ever built, and is now being installed in the latest Surface Combustion .... Furnace. Photographed in General Alloys Plant. Wall section variation in this casting is less than in any of this type ever produced, which uniformity, plus General Alloys Quality, should insure unusual service.

Surface Combustion Corporation gladly paid General Alloys Company several cents more per pound for this muffle, than "Cheap" alloy makers prices, which extra quality is the cheapest insurance ever written on alloy. General Alloys stands squarely behind their products. Furnace Engineers, Furnace Salesmen, and Furnace Buyers *know* that. Specify General Alloys parts in your furnaces, insure dependability, save headaches.

RETORTS ALL TYPES AND SIZES

The photo-engraver's artist darn near ruined the contour of this casting when he painted in that black background for contrast. He also forgot to press the young man's pants.

Any foundryman will tell you that casting a tube of two diameters and an offset like this one is intriguing. Add to that an internal spiral feed screw and the game gets exciting, calls for New England Craftsmen.

We make retorts of all types and sizes for high temperature and corrosion resistant applications, to operate at lowest-cost-per-heat-hour of service.

As Consulting Engineer for American Interests I went very thoroughly into Dirigibles, nearly purchased for trans-Atlantic service the R-100, Commander Burney's spiral-tube-girder dirigible which was built for the British Conservative Government, and left 95% complete in its hangar when the Laborites went into power and built the misegenation known as R-101, the wreck of which erased the best men in the Royal Air Corps.

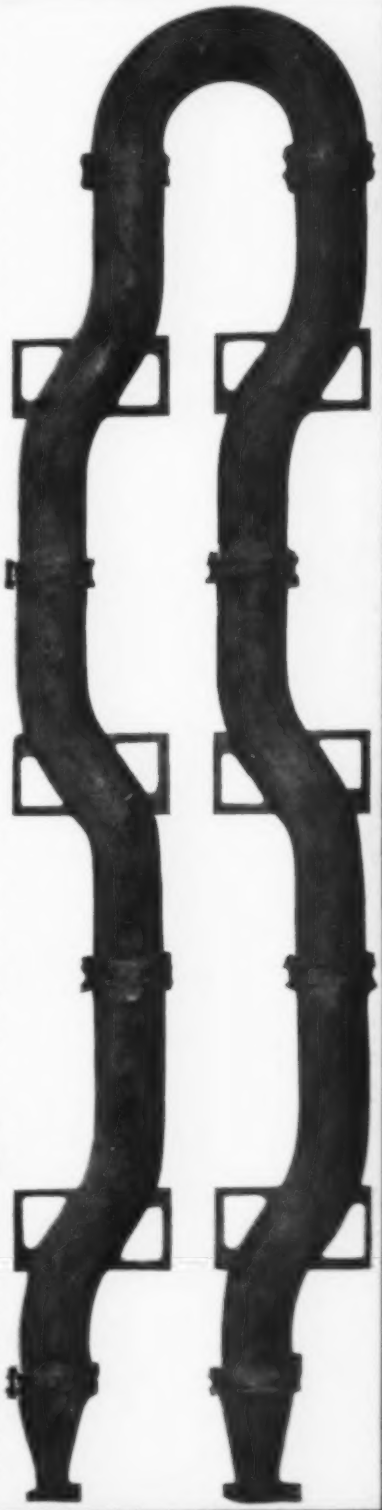
The Government wouldn't complete Burney's ship and finally blocked his sale of it to Americans. One of the catches was at that time, the only hangar in the world outside of Germany that would house her, was in England. It would have cost as much to stable the nag as to buy her. The low down is: Helium is safe but cuts the pay load below that which can be carried by Hydrogen so greatly as to change the whole economic set-up.

In the event of war it is probable that any military power would discard Helium, use Hydrogen, risking inflammability to get the greatly increased bomb carrying capacity, and the greater fuel load for an enlarged cruising range.

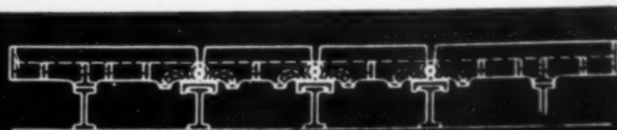
(Continued on Page 8)

RADIANT TUBES

The Combustion tube heating elements, known as "Radiant Tubes" on the right are eliptical in cross section and scientifically contoured to secure a uniformity and intensity of heat distribution previously unknown. These tubes are being installed in the most unusual enameling furnace ever built for one of the highest quality enameling concerns in America, by the Surface Combustion Corporation. This thoroughly engineered job is far advanced over the usual "Burner stuck in a tube" type of radiant tube installation. Substantial cast G.A. tubes give long, dependable life.

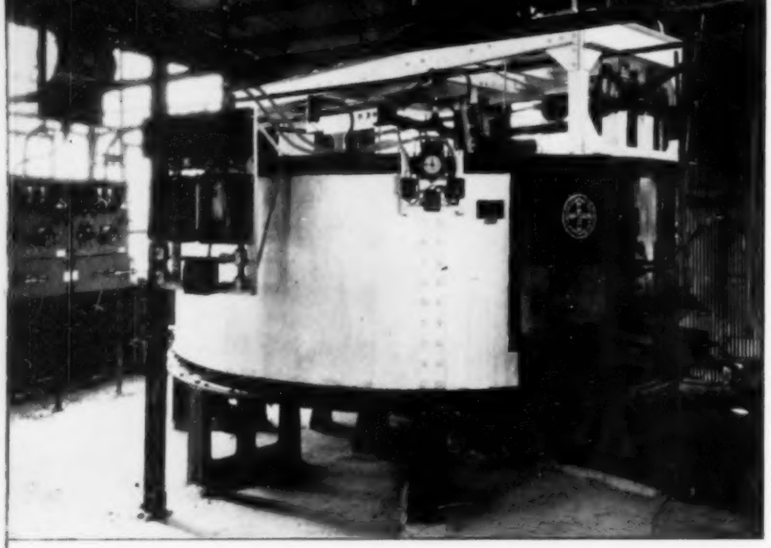


...hinge 4-rail tray will weigh approximately 60 lbs.



A three hinge 5-rail tray will weigh approximately 48 lbs.

THE SAVING IS OBVIOUS



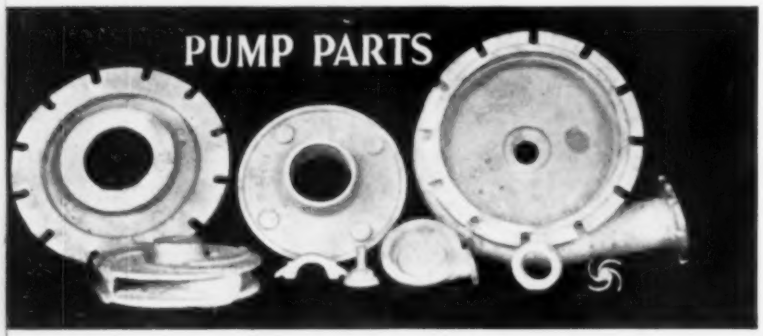
HAGAN ROTARY HEARTH FURNACES

FOURTEEN years of experience with Hagan Rotary Hearth Furnaces, equipt with Q-Alloy and X-ite hearths, have proven to a score of industries the dependability, economy, and production capacity of this type HAGAN furnace. Alloy hearth plate life usually runs from five to ten years depending on grade, temperature, and usage.

OPERATING DATA

BOTH fixed and tilting automatic discharge segmental hearth types in a variety of sizes and capacities are available for everything from annealing forgings to box carburizing.

Operation-Hardening Misc. small forgings.
Type—Rotary Hearth, Automatic Discharge.
Production—1000 lbs. per hour.
Operating Temperature—1560° F.
Fuel—Electricity.
Drive—Hearth and Door Drives—motor—automatic. Hearth movement, dumping of trays and door operation all under control of automatic repeating process instruments.



UNEQUALLED FOUNDRY PRACTICE

IF you are interested in American Craftsmanship, write for our Bulletin No. 1, which shows the greatest variety, intricacy, and metallurgical range of castings ever produced by any plant anywhere.

SEND US YOUR INQUIRIES FOR CORROSION RESISTANT CASTINGS

THE A.S.M. had a fine meeting at Battelle Memorial Institute in Columbus, where I got a kick out of finding my old piece on "FERRO-MANUREIUM" hanging in Dr. Gillett's office. I'll have to reprint that soon for the new generation of rising Metallurgists.

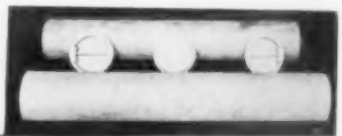
THAT mile long Frigidaire plant at Morraine gave me a tough battle. When I'd get up high enough to photograph it I'd get into the clouds, and when I came down, it wouldn't fit in the camera. I finally shot it through a hole.

Speaking of air-photos, L. W. Kohls, Surface Combustion Erection Engineer, can *take it*. I had him up for an hour and a half shooting the whole town of Rochester, and stalling the ship every shot for over a hundred stalls in a high wind. That boy will make a pilot.

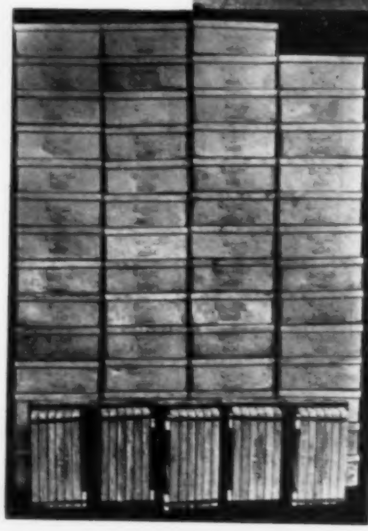
THE Eades Bridge, St. Louis, is so charged with static that you get an inch long spark when you pay toll. A swell idea to extend to tax collectors generally, if Polarity was reversible.

THE human-skin-tannery story came to light again recently when I encountered a Doctor with a medicine case of Human Skin. The choicest part of the hide comes fro[m] back—shoulders to buttocks. ... buried face up, fully clothed ... corpse could serve a useful pu[rpose] by donating hide that would ... be missed, might even help a s[trug]gling student complete his st[udies]. You can kid any undertaker a[bout] this "By-Product" of his busine[ss] start a merry argument. Think ... when you say, "That's no skin o[ff my] tail."

CARBURIZING
POTS—BOXES—TUBES—
RETORTS—MUFFLES



THE MOST COMPLETE DESIGN SELECTION BACKED BY UNEQUALLED EXPERIENCE



FLYING along I felt a bump like ru[nning] over a log, something you don't do i[n an] airplane, so I put in at the next ai[rport] to find one of my "Tail wires," ru[dder] post brace wires, hanging. It had ... on a thread, from fatigue. Vic. Ho... berg, star Metallographist at Mass. ... had a micrograph made, showing so... structure, reproduced herewith. A ... wire was installed. Then the fitti[ngs] go. As I was taking off from Detroi[t Air]port, the Tower radio operator ph[oned] "Your tail feathers are hanging,"—th... to Radio! I scrapped all wires an[d fit]tings, installed new.

THE New England Council has ... lished a beautifully illustrated book[let] titled, "Your Vacation in New Engl[and]." Drop us a line and we'll gladly send ... copy.